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VOL III - PART 1



FULL-SCALE INCINERATION SYSTEM
DEMONSTRATION VERIFICATION TEST
BURNS AT THE NAVAL BATTALION CON-
STRUCTION CENTER, GULFPORT, MIS-
SISSIPPI - VOL III: TREATABILITY TESTS
PART 1

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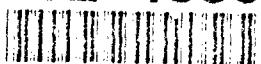
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19. ABSTRACT (Continue on reverse if necessary and identify by block number) This technical report is divided into eight volumes. This portion of the report comprises Volume II, which is further subdivided into 5 parts, including the appendixes. This volume describes the verification test burns conducted on a 100 ton/day mobile incinerator that was used to process soil contamination with the constituents of Herbicide Orange, namely 2,4,5-T, 2,4-D, and trace quantities of dioxin. The demonstration was conducted at the Naval Construction Battalion Center in Gulfport, Mississippi. This volume provides specific details concerning the planning efforts and data results from the test burns. Project managers and field engineers responsible for planning and implementation of hazardous waste remedial actions should find the information contained herein very useful.			
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EXECUTIVE SUMMARY

In December 1986, the mobile waste incinerator system, MWP-2000, manufactured and operated by ENSCO Environmental Services of El Dorado, Arkansas, was used to successfully treat soil contaminated with 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD) at the Naval Construction Battalion Center (NCBC) in Gulfport, Mississippi. The contamination resulted from earlier spills at a herbicide orange (HO) storage area at NCBC. The mobility and availability of this plant provided a means of demonstrating the incinerator technology at full size under field conditions as part of the research, test, and evaluation phase of the U.S. Air Force Environmental Restoration Program, sponsored by the Air Force Engineering and Service Center (AFESC). This report covers the verification test burns, which was the first phase of three phases. The other two phases, trial burns and evaluation of soil remedial operations, are reported separately in References 1 through 7 as shown in Figure ES-1.

The MWP-2000 incinerator system is designed to destroy and detoxify solid, semisolid, and/or liquid wastes. Most components are installed on trailer flatbeds, platforms, or skids to facilitate the movement of the system from location to location to perform onsite cleanup of contaminated sites. Major components of the system are (1) a waste feed system, (2) rotary kiln with outlet cyclones, secondary combustion chamber (SCC) with an auxiliary feed system, air pollution control train, storage tanks and other support equipment. Soil is fed to the kiln where it is exposed to temperatures in the 1200-1800°F range. Soil and gases exit the kiln, where the soil is collected and the gases pass through a cyclone, to separate out particulates, and enter the SCC. The gases are raised to a temperature of 2100-2200°F in the SCC to complete destruction of primary organic hazardous constituents that are present. Exiting gases flow through the air pollution control train and out the stack. The kiln and SCC were fueled by natural gas at the NCBC site.

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Project Summary Volume 1 Reference 1		Verification Burn Volume 2 Reference 2			Trial Burn Volume 3 Reference 2			Incinerator Operations Volume 4 Reference 3			Excavation Availability Volume 5 Reference 4			Soil Site Services Volume 7 Reference 6			Management & Delisting Volume 8 Reference 7							
Verification burn	Site setup descriptor	Site setup description	Burn	Volume 3	Reference 2	Incinerator activities	Operations Volume 4	Reference 3	Incinerator activities	Availability Volume 5	Reference 4	Excavation	Excavation	Site Services Volume 7	Reference 6	Delisting Volume 8 Reference 7	Justification and need for delisting	Public relations	Subcontractor relations	Planned approach	Sample approach	Sample analysis & data results	VHS/OLM model	Recommendations
Trial burns	Soil feedstock	Feedstock	Burn	Volume 3	Reference 2	Sampling	Sampling	Sampling	Decontamination and demobilization	Productivity improvements and process changes	Productivity improvements and process changes	Soil storage	Emergency procedures drills	Required site services	Availability data results	Availability data results	Emergency procedures drills	Emergency procedures drills	Emergency procedures drills	Emergency procedures drills	Emergency procedures drills	Emergency procedures drills	Emergency procedures drills	
Soil excavation	Incinerator activities	Incinerator activities	Incinerator activities	Incinerator activities	Incinerator activities	Data results	Data results	Data results	Data collection during decontamination and demobilization	Data collection during decontamination and demobilization	Data collection during decontamination and demobilization	Availability data results	Availability data results	Availability data results	Availability data results	Availability data results	Availability data results	Availability data results	Availability data results	Availability data results	Availability data results	Availability data results		
Incinerator operations	Data results	Data results	Data results	Data results	Data results	Project Management & Site Services	Project Management & Site Services	Project Management & Site Services	Delisting	Delisting	Delisting	Delisting	Delisting	Delisting	Delisting	Delisting	Delisting	Delisting	Delisting	Delisting	Delisting	Delisting		

Figure ES-1. NCBC demonstration project report breakdown.

Five verification test burns were conducted and evaluated for a range of operating conditions, processing 100 tons of contaminated soil under a Research, Development, and Demonstration (RD&D) permit issued by the U.S. Environmental Protection Agency (EPA), Region IV, in accordance with the Resource Conservation and Recovery Act (RCRA) of 1976, as amended. Soil feed rates ranged between 2.8 and 6.3 ton/hr. Average kiln temperatures for the five test burns varied between 1355 and 1645°F. The SCC average temperatures for the five test burn varied between 2097 and 2174°F.

Samples of feedstock, treated soil, stack gas, liquid waste effluent, and ambient air were taken by Versar, Inc. of Springfield, Virginia, for each test burn and sent to IT Analytical Services of Knoxville, Tennessee, for analysis. The stack sampling consisted of EPA Modified Method 5 and volatile organic sampling train. Laboratory methods and protocols were drawn from EPA Contract Laboratory Program (CLP) procedures. The analytical results were independently evaluated within method/protocol requirements and were found acceptable.

The AFESC goal was to treat the soil polychlorodibenzo-p-dioxin/polychlorodibenzofuran (PCDD/PCDF) congener sum (tetra, penta, hexa) to less than 1.0 ppb; all test burns verified that the goal was not the congener sum ranged from 0.009 to 0.021 ppb with the maximum concentration occurring for a test burn during conditions of lowest average kiln temperature (1355°F) and highest average soil feedrate (6.3 tons/hour). The 2,3,7,8-TCDD concentration averaged 44 ppb in the five feedstock samples with the range from 36 to 56 ppb. The total TCDD averaged 46 ppb and ranged between 32 and 61 ppb. Neither 2,3,7,8-TCDD nor total TCDD were detected in the treated soil samples. The detection limits varied from 0.0001 and 0.0054 ppb through the use of high resolution mass spectrometer (HRMS). The calculated soil-to-ash removal efficiencies (SAREs) for the treated soil ranged between 99.9921 and 99.9966 percent for 2,3,7,8-TCDD and between 99.9952 and 99.9984 percent for total TCDD. In all cases, these represent lower bounds, because the detection limits were used in the calculations for the treated soil concentrations.

Herbicide orange constituents 2,4-dichlorophenoxyacetic acid (2,4-D) and 2,4,5-trichlorophenoxyacetic acid (2,4,5-T), present in the feedstock samples at ranges of 23 to 3300 ppb and 47 to 840 ppb, respectively, were removed by the incinerator process to nondetectable levels (20 and 2 ppb, respectively), in the treated soil samples. The soil SAREs ranged between 99.9130 and 99.9994 percent for 2,4-D and between 99.9957 and 99.9998 percent for 2,4,5-T. In all cases these SAREs are lower bounds because detection limits were used for the treated soil. Most significantly, the highest SARE for 2,4,5-T was obtained during the test burn of lowest average kiln temperature (1355°F) and highest average soil feed rate (6.7 ton/hr).

The treated soil produced by the incinerator process from NCBC HO-contaminated soil was evaluated against the EPA delisting criteria. The delisting criteria are the standards that EPA uses to determine if the waste can be removed from the regulatory list of hazardous waste. Because the treated soil is not corrosive, ignitable, or reactive and because it passes the requirements for the EP toxicity test, the requirements of 40 CFR 261.21-261.24 can be satisfied. Additionally, the soil treated in the Verification Test Burn meets the delisting criteria specified.

The MWP-2000 incinerator system demonstrated that two of the three EPA mandated performance standards could be met. These were chloride and particulate emissions. Sample analysis of stack gas showed chloride concentrations of 0.29 µg/m³ or less for all test burns, which is well below the EPA limit of 1.8 kg/hr in 40 CFR 264.343(b). Also particulate concentrations were 49.7 mg/dscm or less for all test burns, which is well below the limit of 180 mg/dscm in 40 CFR 264.343(c).

The incinerator destruction and removal efficiency (DRE) of 2,3,7,8-TCDD could not be demonstrated by the process because the dioxin concentration in the HO-contaminated soil was not sufficiently high to be able to calculate a DRE meeting the EPA limit of six nines specified in 40 CFR 264.343(a). No 2,3,7,8-TCDD was detected in the stack gas samples,

and HRMS was used to achieve lowest possible detection levels ($0.22\text{-}0.32 \mu\text{/m}^3$). Six nines were demonstrated ranging from 99.9968 to 99.9985 percent.

Destruction and removal efficiencies of six nines were demonstrated for the herbicides 2,4-D and 2,4,5-T on at least one test burn. Because of its higher initial concentrations in the HO-contaminated soil and lower analytical detection level (factor of 10), the DRE results were better for 2,4,5-T than for 2,4-D with a range of 99.9968 to 99.9999 percent. Two test burns met six nines; however, EPA recommends that three test burns should meet this performance requirement. The 2,4-D range was 99.9736 to 99.9999 percent with one test burn having a DRE of six nines. Because neither herbicide was detected in the gas samples, detection limits were used in the DRE calculations giving a lower bound value. One of the test burns showing a DRE of six nines for 2,4,5-T, occurred during the most severe operating condition among the five test burns. The herbicide DRE results provide a significant indication of the incinerator system capability to meet EPA DRE performance requirements for principal organic hazardous constituents (POHCs).

For the feedstock conditions that prevailed during the test burns, the incinerator process demonstrated that the liquid effluent waste generated during the operations met the requirements specified in the Publically Owned Treatment Works permit issued by the Mississippi Department of Natural Resources.

During all phases of operation monitored by ambient air sampling, the particulate concentrations were quite low ($<0.11 \text{ mg/m}^3$ average concentration for any sample) compared to the TLV for total dust at 10 mg/m^3 . Ambient levels of 2,4-D and 2,4,5-T were also low, being at least a million times below the TLV of 10 mg/m^3 that applies for both compounds. These results demonstrate that the activities associated with this soil restoration process can be done safely.

During testing, mechanical problems occurred that affected the accomplishment of the verification test burns and, could likely impact the subsequent soil restoration process. All of the problems are either

mechanical- or personnel-related rather than a technological failure of the incinerator system. Three significant problems were associated with the soil feed system: (1) moist soil bridging above the rotary auger in the feed hopper, (2) shredder reliability due to the nature of the cement-stabilized NCBC soil, and (3) determination and control of mass feed rate. Cleaning of the boiler, resulting from the particulate carryover from the SCC proved to be awkward to perform and operationally time consuming. Review of SCC temperature records shows that improved incinerator process operator awareness is needed to maintain good temperature control.

The following major recommendations were made following the evaluation of MWP-2000 verification test burns:

1. The MWP-2000 incinerator process should be considered as an acceptable technology for treating dioxin-contaminated soils of relatively high feed rates (5-6 tons/hour). This technology can process soil and other inorganic solids with little pretreatment and uses conventional equipment.
2. The MWP-2000 incinerator process also should be considered as a technology for detoxifying soils contaminated with other organic compounds.
3. The DRE performance for 2,3,7,8-TCDD could not be demonstrated because of low concentrations in the feedstock; therefore, it was recommended that trial burn testing at NCBC be performed with surrogates acceptable to the EPA to demonstrate six nines DRE.
4. The problems identified as a result of this testing should be investigated by ENSCO for possible design and/or procedural changes that would improve the system operability and reliability.

5. At the beginning of a restoration project, there should be emphasis on supervision and training of system operators to ensure understanding and awareness of control responsiveness, especially to avoid reaching operating limits that require mitigating actions.

PREFACE

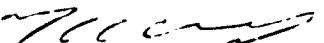
This report was prepared by EG&G Idaho, Inc., P. O. Box 1625, Idaho Falls, ID 83415, under Job Order Number (JON) 2103 9027, for the Air Force Engineering and Services Center, Engineering and Services Laboratory, Tyndall Air Force Base, Florida 32403-6001.

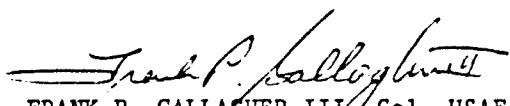
This report summarizes work done between September 1986 and December 1986. Major Terry Stoddart and Major Michael L. Shelley were the AFESC/RDVS Project Officers.

The information contained in this volume describes the events, the planning efforts, and the data results of a test burn conducted on a 100 ton/day mobile incinerator that was used to process soil contaminated with constituents of herbicide orange. This volume is subdivided into five parts; Part 1 contains the final report on the verification test burns, Parts 2 through 5 contain the appendixes. Volumes I and III through VIII describe the incinerator operations, the soil excavation activities, and the additional testing required by the Environmental Protection Agency.

This report has been reviewed by the Public Affairs Office (PA) and is releasable to the general public, including foreign nationals.

This report has been reviewed and is approved for publication.


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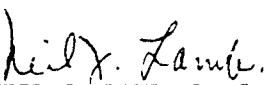

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LIST OF ABBREVIATIONS

2,4,5-T	2,4,5-trichlorophenoxyacetic acid
2,4-D	2,4,-dichlorophenoxyacetic acid
AFESC	Air Force Engineering and Services Center
APR	Air-purifying respirator
ASTM	American Society for Testing and Materials
AWFSO	Automatic waste feed shutoff
BNA	Base/neutral/acid
BOD	Biological Oxygen Demand
CCSP	Contract Compliance Screening Procedure
CDC	Centers for Disease Control
CFR	Code of Federal Regulations
CLP	Contract Laboratory Program
COD	Chemical Oxygen Demand
CRDL	Contract Required Detection Limit
DAS	Data Acquisition System
DDAG	Dioxin Disposal Advisory Group
DLV	Detection Limit Value
DOD	Department of Defense
DRE	Destruction and Removal Efficiency
ECD	Electron Capture Detection
ENSCO	Environmental Services Company
ENT	Effluent Neutralization Tank
EP	Extraction Procedure
EPA	Environmental Protection Agency
GC/MS	Gas Chromatography/Mass Spectrometry
GFAA	Gas Flame Atomic Absorption
HEPA	High-Efficiency Particulate Arresting
HO	Herbicide Orange
HPLC	High Pressure Liquid Chromatography
HRGC	High Resolution Gas Chromatograph
HRMS	High Resolution Mass Spectrometry
HSWA	Hazardous and Solids Waste Amendments

LIST OF ABBREVIATIONS
(CONTINUED)

ICP	Inductively Coupled Plasma
INEL	Idaho National Engineering Laboratory
ITAS	International Technologies Analytical Services
JI	Johnson Island
LRMS	Low Resolution Mass Spectrometry
M5	Method 5
MM5	Modified Method 5
MWP-2000	Mobile Waste Processor-2000
NCBC	Naval Construction Battalion Center
OCDD	octachlorinateddibenzodioxin
OCDF	octachlorinateddibenzofuran
OEHL	Occupation and Environmental Health Laboratory
OLM	Organic Leachate Model
OLM	Organic Leachate Model
PAH	Polynuclear Aromatic Hydrocarbon
PAPR	Powered-Air Purifying Respirator
PCB	polychlorinatedbiphenyls
PCDD	polychlorinateddibenzodioxin
PCDF	polychlorinateddibenzofuran
PIC	Partially Incomplete Combustion Products
POHC	Principal Organic Hazardous Constituent
POTW	Public-Owned Treatment Works
PPL	Priority Pollutants List
ppb	part per billion (10E-9)
ppm	part per million (10E-6)
ppq	part per quadrillion (10E-15)
ppt	part per trillion (10E-12)
PUF	Polyurathane Foam
QA/QC	Quality Assurance/Quality Control
QAPP	Quality Assurance Project Plan
RCRA	Resource Conservation and Recovery Act
RD&D	Research, Development, and Demonstration
REs	Removal Efficiencies

LIST OF ABBREVIATIONS
(CONCLUDED)

SARE	Soil to Ash Removal Efficiency
SCC	Secondary Combustion Chamber
SHV	Standard High Volume
SOP	Standard Operating Procedure
TCDD	tetrachlorinateddibenzodioxin
TCDF	tetrachlorinateddibenzofuran
TCLP	Toxicity Characteristic Leachate Procedure
TLV	Threshold Limit Value
TOC	Total Organic Carbon
USAF	U.S. Air Force
VHS	Vertical Horizontal Spread
VOST	Volatile Organic Sampling Train
WBGT	Wet Bulb Globe Temperature

SECTION I

INTRODUCTION

A. OBJECTIVE

The purpose of this program is to demonstrate the reliability/maintainability and cost-effectiveness of a mobile rotary kiln incinerator system for soil cleanup and restoration at an Herbicide Orange (HO)-contaminated site. The mobile waste incineration system, Model MWP-2000, manufactured and operated by ENSCO Environmental Services of El Dorado, Arkansas, was selected for the Air Force Full-Scale Demonstration Program. The selected location is a former HO storage site at the Naval Construction Battalion Center (NCBC) in Gulfport, Mississippi. This program is under the sponsorship of the Air Force Engineering and Services Center (HQ AFESC), Tyndall Air Force Base, Florida. Technical oversight and project management services were provided by EG&G Idaho at the Idaho National Engineering Laboratory.

The field demonstration of the program was organized into three phases to meet the U.S. Environmental Protection Agency (EPA) requirements for the research, development, and demonstration (RD&D) permit:

1. Preoperational test burns to verify technical performance and provide data for a range of soil feed rates.
2. Trial burn to ensure conditions of Resource Conservation and Recovery Act (RCRA) permit can be met.
3. Continuous operation to provide reliability and maintainability data.

This report discusses the activities associated with the first phase. The two other phases are separately reported in References 1 through 7.

A specific goal of this technology testing was to reduce the total isomers of tetra-, penta-, and hexachlorodibenzo-p-dioxin and respective isomers of polychlorodibenzofuran to less than 1 part per billion (ppb). The overall soil treatment goal of the demonstration was to reduce the level of contaminants to criteria approved by EPA Headquarters, which would facilitate the removal of the waste from the EPA list of hazardous waste under the auspices of the Resource Conservation and Recovery Act (RCRA) of 1976, as amended by the Hazardous and Solids Waste Amendments (HSWA) of 1984.

B. BACKGROUND

HO is primarily composed of two compounds, 2,4-dichlorophenoxyacetic acid (2,4-D) and 2,4,5-trichlorophenoxyacetic acid (2,4,5-T) and various esters of these two compounds. It was sprayed as a defoliant in Vietnam during the 1960s and at Eglin Air Force Base, Florida, between 1962 and 1970 (References 8,9). Due to the close proximity of NCBC to the deep water port of Gulfport, MS, the NCBC was used as a short term storage and trans-shipment area for drums of HO enroute to southeast Asia. Drum storage at the site varied between 6 and 18 months.

Early in 1970, the herbicide 2,4,5-T was reported a teratogen in mice and rats (Reference 10). More specifically, studies identified an unwanted by-product 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD), which is contained in 2,4,5-T, as the reason for the teratogenic effects (Reference 11). DOD discontinued the use of HO in 1970 (Reference 12). At that time, the remaining continental U.S. stockpile, 850,000 gallons of HO were stored at NCBC and 1,370,000 gallons located in South Vietnam were shipped to JI for storage (Reference 13).

During the summer of 1977, the entire 2.2 million gallon HO stockpile was disposed of at sea by high temperature incineration (Project PACER HO, Reference 13 and 14). However, spills during the storage and handling of HO left the soil at the storage area contaminated with dioxin. The Air Force Logistics Command Plan and EPA permits for the disposal of HO committed the Air Force to a follow-up storage site reclamation and

environmental monitoring program (Reference 13). Immediately following the at-sea incineration, the U.S. Air Force Occupation and Environmental Health Laboratory (USAF/OEHL) initiated site monitoring studies of chemical residues in nearby soil, drainage water, and drainage ditch sediment at the former NCBC HO storage site (References 13 and 15).

To accomplish the goal of returning the former HO storage site to full and beneficial use, the Air Force utilized the technical capabilities of the Department of Energy's (DOE) Idaho National Engineering Laboratory and, in particular, EG&G Idaho, a DOE contractor. In 1984, the Air Force and EG&G Idaho coordinated a site characterization study (Reference 16). The Air Force and EG&G Idaho continued the remediation investigation by conducting two small scale demonstration projects to demonstrate the feasibility of two different technologies for the removal of dioxin from HO contaminated soil (References 17 and 18). Although those demonstrations were successful, the technologies were not sufficiently developed to use for a full scale site remediation.

When the small scale demonstrations were completed, the Air Force still had little data with which to accurately predict the cost and feasibility of remediating large quantities of contaminated soil. Therefore, the Air Force coordinated with EG&G Idaho to demonstrate a full scale demonstration project in which cost and reliability data would be collected while the site was being remediated.

As described in Section I.B.2, rotary kiln incineration was chosen as the technology most likely to be cost efficient and reliable. Therefore, bids were solicited from a variety of incinerator contractors; those bids were evaluated and Environmental Services Company, Pyrotech Division, now known simply as ENSCO, was chosen. While ENSCO provided the equipment and operational personnel for the incinerator, EG&G Idaho provided the expertise in overall project management, EPA permitting, regulatory compliance, data base management, and sampling.

1. Restoration Criteria

Of the polychlorodibenzo-p-dioxin/polychlorodibenzofuran (PCDD/PCDF) isomers, the 2,3,7,8-TCDD isomer is considered to be the most toxic to man (Reference 19). This toxicity may be 10 times as toxic as the next isomer within this group (Reference 20). The Centers for Disease Control (CDC) of the U.S. Department of Health and Human Services in Atlanta, Georgia, studied the risks of various concentrations of 2,3,7,8-TCDD in soil and concluded that residual soil levels at or above 1 ppb of 2,3,7,8-TCDD in residential areas represent a level of concern (Reference 21). In certain commercial areas, the CDC felt higher (but undefined) levels in the soil may represent an acceptable risk to nonoccupationally exposed individuals. However, the CDC also concluded that, on ranges and pastures, lower concentration levels in the soil may still be of concern since the 2,3,7,8-TCDD accumulates in the tissues of grazing cattle and rooting swine (Reference 21).

In a November 7, 1986, Federal Register notice (Reference 22), EPA proposed a standard for land disposal of PCDD/PCDF containing waste material. The proposed standard required that these constituents (i.e., all isomers of tetra-, penta-, and hexachlorodibenzo-p-dioxins and dibenzofurans) be below a 1 ppb limit in the waste extract before being land-disposed. Further, wastes having concentrations that meet or exceed this limit may be treated in accordance with the criteria for incineration (40 CFR 264.343 and 265.352) and thermal treatment (40 CFR 383) for dioxins. Criteria considered for full-scale restoration projects undoubtedly will depend on regulatory requirements in effect at the time and cost effectiveness of the technologies being considered.

2. Technical Assessment and Selection

The following major approaches to managing soil containing PCDD/PCDF existed at the time of project planning:

1. Excavation and off-site disposal or treatment.
2. Excavation and onsite storage and treatment.

The costs incurred by transportation and disposal or treatment at EPA-permitted hazardous waste facilities presently eliminate Option 1 as a near-term environmental restoration technology. Furthermore, due to the November 7, 1986, Land Ban Rule discussed in the previous section, dioxin waste cannot be land-filled. Onsite treatment of PCDD/PCDF in soil has great social and political appeal. Furthermore, restoration costs are reduced and transportation of the soil is eliminated.

Alternatives are classified as chemical, biological, thermal, and physical; the availability of laboratory, pilot-scale, or demonstration-scale data relates to either dioxin or similar organic compounds. The following list of technologies was evaluated to select the process for the full-scale demonstration. Details of the study are presented in Appendix A.

Chemical Treatment

- UV photolysis
- Alkalide polyglycoxide process
- Chemical oxidation with catalyst
- Wet oxidation (catalyzed wet oxidation, supercritical fluids, organo-metals dechlorination process, and hydrazine reduction process)

Microbial Treatment

- Preliminary microbial metabolism
- Preliminary enzyme applications

Thermal

- Incineration
- Microwave plasma detoxification
- Vitrification
- Plasma arc pyrolysis
- Corona glow processing
- Radio frequency detoxification

Separation and Concentration Technologies

- Extraction
- Adsorption
- Distillation/stripping

A rotary kiln incinerator was chosen as the best available technology to demonstrate reliability and maintainability to achieve the stated goal at the lowest cost. The rotary kiln was chosen because of the availability of rotary kiln incineration data, the mobility of the proposed incinerator, and the lack of detailed data from the other processes considered. Although other alternatives could be made portable, the proposed incinerator was already portable and manufactured with existing readily available components. Laboratory studies have shown that removal of 2,3,7,8-TCDD in the soil residue at temperatures above 1470°F can be greater than 99 percent (Reference 17). Herbicide Orange contaminated with 2,3,7,8-TCDD was successfully incinerated at sea in the 1970s (Reference 7). Furthermore, rotary kiln incineration is a proven technology for a variety of other incineration needs.

3. Storage Site Location

NCBC is a fenced, limited-access military installation (Figure 1). It is a land area of several square miles located approximately 2 miles from the Gulf of Mexico and is approximately 20 feet above sea level. The indigenous soil is sand to sandy loam, intermixed with some clay.

Approximately 16 acres at NCBC served as an HO storage site. During the temporary storage phase, the HO drums were stacked within three zones (A, B, and C), shown as shaded areas in Figure 2. The stacks in Zones B and C covered 40 foot wide by 1200 foot long strips along the indicated roadways (Figure 3). The storage of filled drums during 1970-1977 occurred only in Zone A. Approximately 30 years ago, the storage site was stabilized with Portland cement. The stabilized soil provided a hardened storage area for heavy supplies and equipment. Over the years, additional fill materials (shell, rock, soil, asphalt, and tar) were added to the storage area, providing a cover up to several inches over the cement-stabilized soil. Through use, the contaminated site is now approximately 18 acres. The total area where HO was stored was approximately 16 acres. Due to the storage pattern, however, all of Areas A, B, and C were left unusable; those areas comprise approximately 31 acres.

During 1980, retention basins were constructed on the storage site to prevent migration off-site of dioxin-contaminated soils by surface runoff. The storage site within the fenced perimeter of Zone A is a restricted area and is not used. Figure 4 provides an overview of the site, primarily Zone A, after the drums were removed.

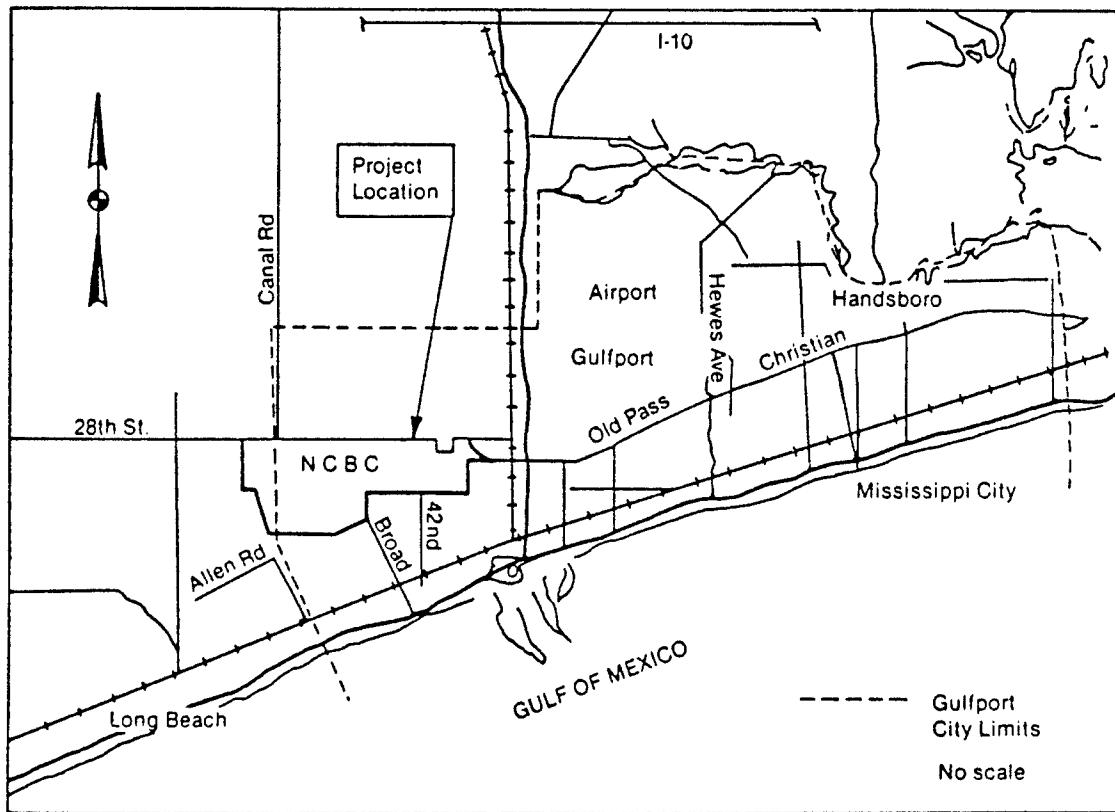


Figure 1. NCBC vicinity map.

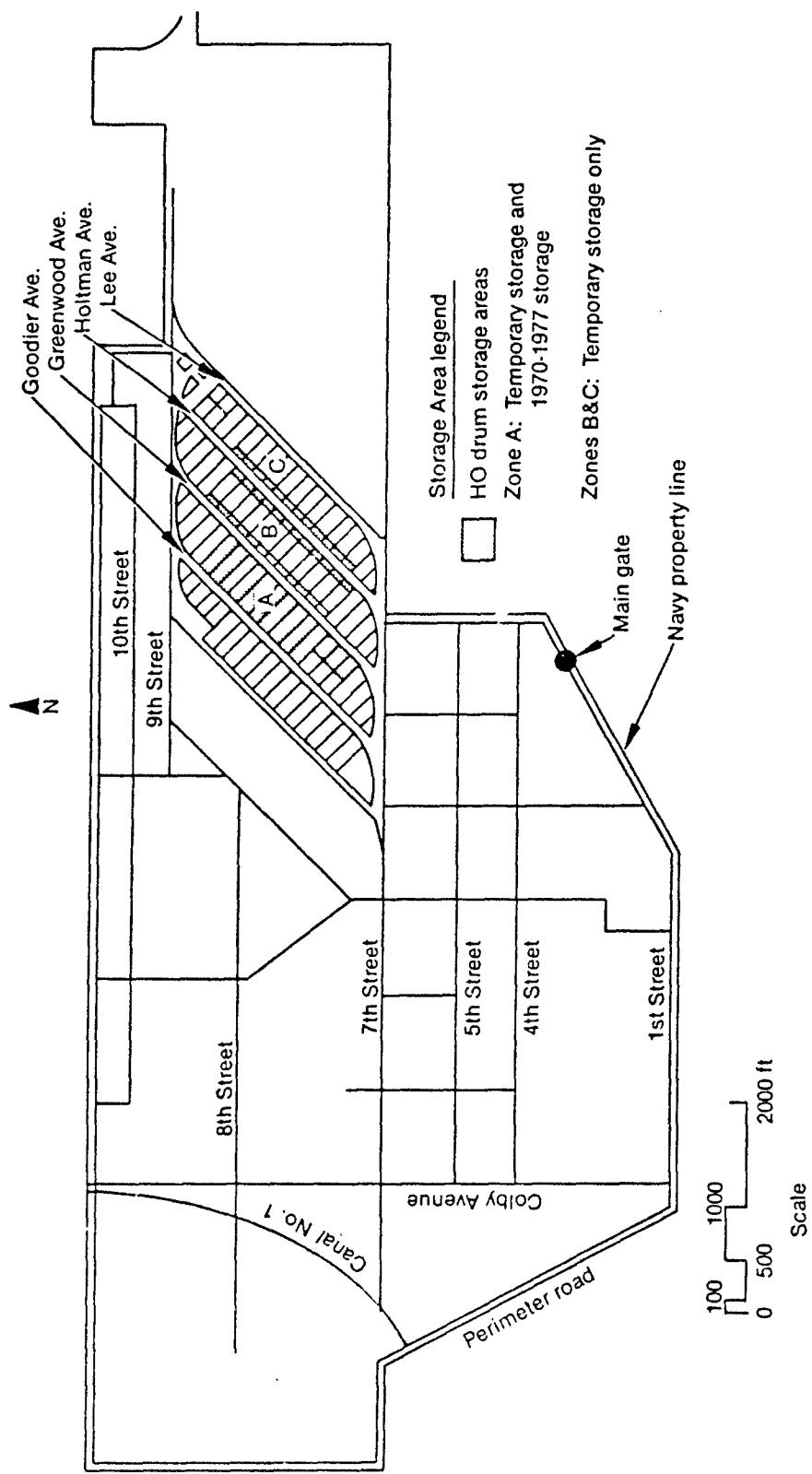
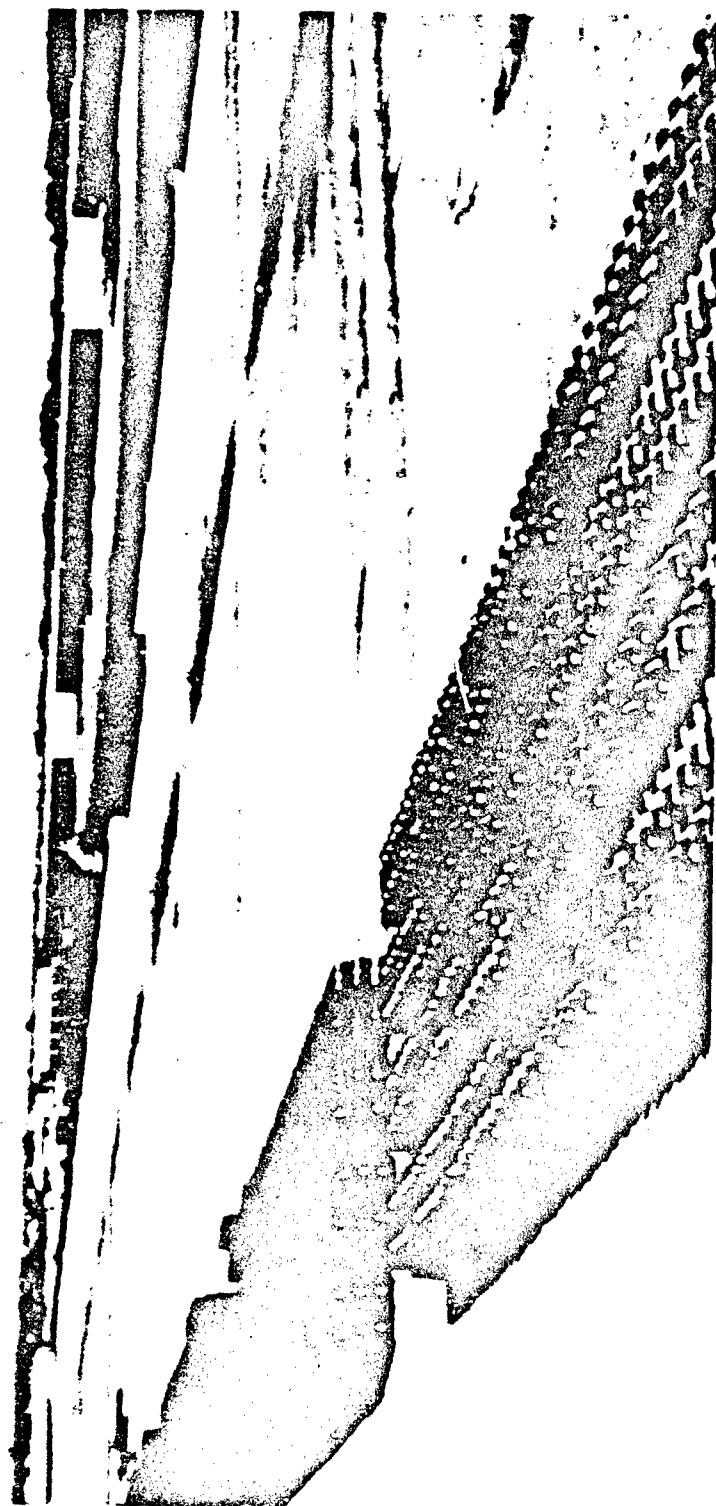


Figure 2. NCBC and location of former herbicide orange storage site.

7-3327

Figure 3. HO drum stacks in NCBC storage zones B and C.



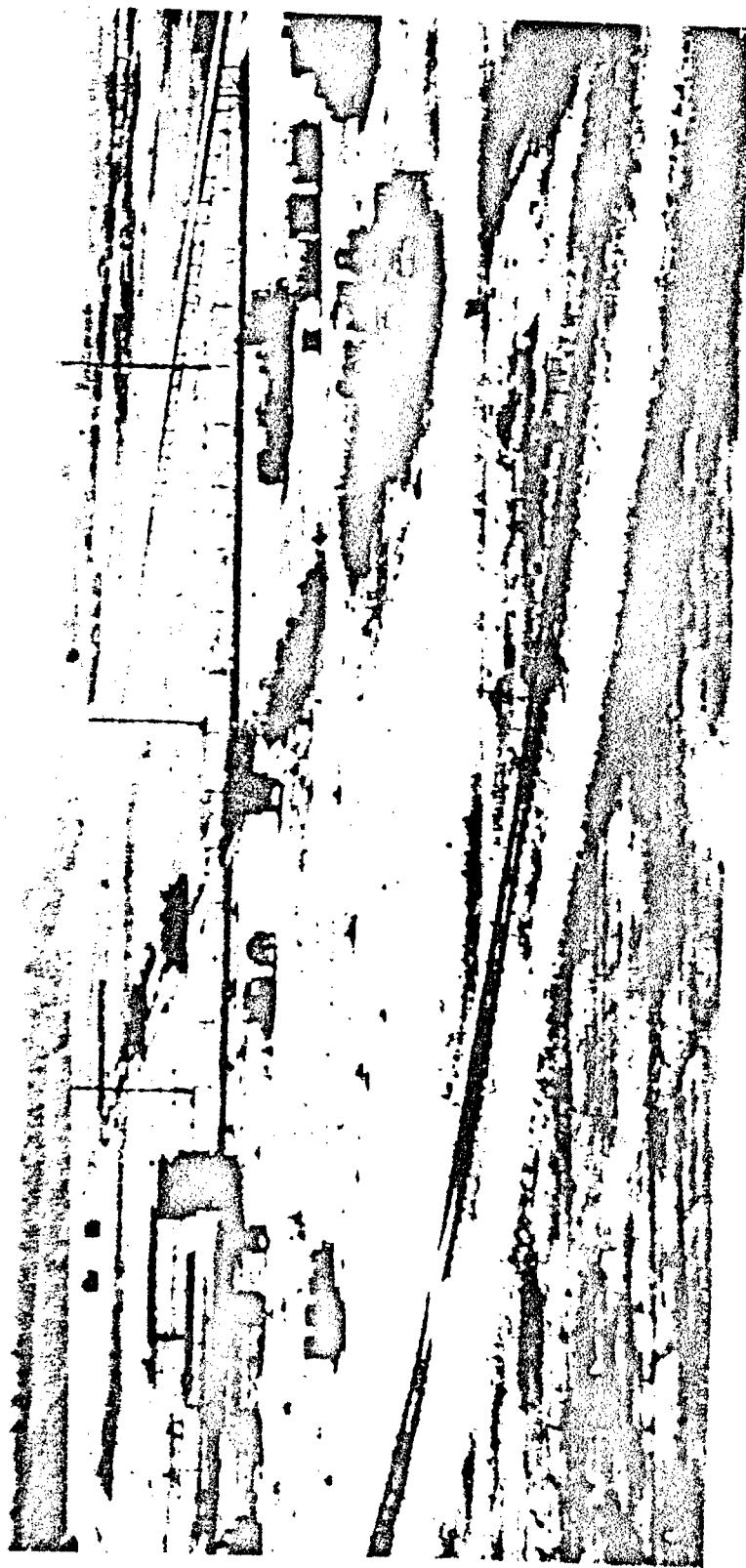


Figure 4. Overview of NCBC storage site Zone A after removal of HO drums.

4. Previous Study

Before demonstration testing, a surface and subsurface soil sampling program was conducted to characterize 2,3,7,8-TCDD concentrations at the HO storage site. Composite sampling was performed in 20-by 20-foot grid plots. Surface concentrations of 2,3,7,8-TCDD for each grid plot are presented in Reference 16. At the soil surface, the maximum indicated "hot-spot" concentration of 2,3,7,8-TCDD was 646 ppb in Zone A. Surface concentrations of 2,3,7,8-TCDD in the contaminated strips in Zones B and C were generally much lower than in Zone A; however, several "hot spots" exceeding 100 ppb were found with the maximum indicated concentration at 344 ppb (Zone B).^a The maximum indicated 2,3,7,8-TCDD concentration found in the 6-inch-thick cement-stabilized subsurface soil was 998 ppb (Reference 16). The vertical extent of 2,3,7,8-TCDD contamination was shown to sharply decrease below the surface layer. For example, at 2 feet, only 5 samples of 35 sample locations showed contamination >1 ppb, with a maximum of 12 ppb (Reference 16). At 5 feet, three of 15 subsurface samples showed contamination >1.0, with a maximum of 5.1 ppb.

5. Environmental Assessment

Prior to the permitting process with EPA Region IV and the State of Mississippi, an environmental assessment (EA) of the proposed RD&D project activities was written and provided to base officials at the NCBC. The purpose of the EA was to assess the environmental impacts. A copy of this draft EA is included as Volume IV to this report. Its major contents and significant conclusions are summarized in the following paragraphs.

Potential direct environmental consequences caused by the project for seven evaluated characteristics are briefly summarized in Table 1.

a. Unpublished data from more recent sampling.

Table 1. Summary of Project Potential Direct Environmental Consequences
 (from Draft Environmental Assessment^a)

Characteristics	Consequences
1. Air emissions	Pollutants produced by incineration (HCl and particulates) will be removed by an air pollution control system, which includes a wet scrubber. Any dioxins in exhaust are expected to be nondetectable (<0.1 ppb). ^b Any other emissions from stack, which are regulated, will be within requirements.
2. Water emissions	Process produces small amounts of waste water (3 gallons/minute) with low concentration of HCl; no neutralization will be needed. Any waste water collected at site will be analyzed to demonstrate compliance with regulatory requirements before being discharged.
3. Effects to rare, threatened, or endangered biological resources	
a. Birds	Former HO storage site does not provide good habitat for three listed species (Southern Bald Eagle, Eastern Brown Pelican, Least Tern) that have been observed there. No nesting areas known. No deleterious effect on any bird population expected.
b. Mammals	One species (Southern Shrew) listed as rare, but the former storage site does not provide suitable habitat. No deleterious effect expected.
c. Reptiles and amphibians	For five species listed (American alligator, Scarlet snake, Southern Hognose snake, Scarlet Kingsnake, Yellow-lipped snake) none would find suitable habitat at the former HO storage site. No deleterious effect expected.
d. Fish	Soil handling plan to be strictly followed to prevent any contaminated silt from entering nearby surface waters (Turkey Creek that flows to Biloxi Bay). No deleterious effect to fish population in Biloxi Bay. Project could have

Table 1. (continued)

Characteristics	Consequences
	beneficial effect on the fish by eliminating any potential for dioxin-contaminated soil entering Turkey Creek.
e. Vegetation	One species, dangleberry (<i>Gaylussacia frondosa</i>) observed on the NCBC site. No deleterious effect expected by project.
4. Socioeconomic impacts	Impact of 21 persons employed as a result of the project is likely to be minimal.
5. Aesthetic effects to the NCBC and Gulfport region	NCBC is in an industrial-type development. No adverse (aesthetic) impacts expected.
6. Effects to archaeological and historical resources	Archaeological survey performed in 1984 showed that there are no archaeological sites or registered national historical landmarks on NCBC.
7. Environmental effects resulting from postulated accidents	
a. Explosion	Because of system's safety interlocks and procedures, such an accident is postulated as hypothetical. Could scatter contaminated dust into the air, but settle out quickly. Possible injuries to operating personnel.
b. Tornadoes and hurricane winds	Shut down process upon Base warning of emergency conditions. Evacuate nonessential personnel. Possible damage to equipment. No adverse environmental or public health consequences expected.
a. For details, see Volume IV.	
b. Detection limits during the verification test burns were 0.32 ng/m ³ or less (see Section V.C.3.a)	

Table 2 summarizes potential indirect consequences for effects to NCBC operations, construction, and waste disposal.

The EA concluded that the proposed full-scale demonstration project would have no significant impact on the environment. This conclusion is based on the findings in Tables 1 and 2. Furthermore, by removing the dioxin contamination hazard from the former HO storage site, the proposed project would improve the environment by not only eliminating the human health hazard, but also by eliminating the possibility of spreading dioxin contamination to offsite areas.

6. Regulatory Authorizations and Public Participation

The HSWA of 1984 gave EPA authority to issue RD&D permits, without promulgation of permitting regulations, which would establish standards for technologies or processes that treat hazardous waste in an innovative and experimental manner. As codified in 40 CFR Part 270.65, these RD&D permits were to help develop safe alternatives for land disposal of hazardous waste, a primary goal of the amendments, by expediting the permitting process to demonstrate the technical and/or economic feasibility of experimental and innovative technologies and processes. In addition, permitting authority was given to regional EPA offices, as well as the authority to modify or waive the permitting and technical requirements applicable to other types of hazardous waste management facilities.

This demonstration fell under the jurisdiction of EPA, Region IV, Atlanta, Georgia, and the RCRA system. An RD&D permit application was submitted to Region IV on January 20, 1986 (Appendix B, Exhibit 1). Copies were also sent to the Dioxin Disposal Advisory Group (DDAG) at EPA Headquarters and the Mississippi State Department of Natural Resources (Bureau of Pollution Control) for coordination. Verbal comments were obtained from EPA, and the application was revised and resubmitted May 9, 1986 (Appendix B, Exhibit 2). Between these submittals, ENSCO trial burn data and ENSCO's revised trial burn plan for polychlorinated biphenyls (PCBs) were made available to Region IV (Appendix B, Exhibits 3 and 4).

Table 2. Summary of Project Potential Indirect Environmental Consequences
(from Draft Environmental Assessment^a)

Characteristics	Consequences
1. Potential effects to operations at NCBC	
a. Utilities	<p>Most significant effect will be on the natural gas system. NCBC rate ranges between 4,000 (summer) and 10,600 (winter) MBtu/month. Incinerator needs would be 24,500 MBtu/month or 2.5, to 6 times existing consumption depending on time of year. Expect to tap into existing gas line (Greenwood Avenue) which is large enough for required gas amounts.</p> <p>Water requirements will be 49,000 gallons/day which is not significant compared to NCBC daily average use of 330,000 gallons/day. A fire hydrant nearby has adequate water main capability.</p> <p>Electricity use expected at 55,000 kWhr/month is small compared to a peak base consumption rate of 2,140,000 kWhr/month during the summer.</p>
b. Operations	<p>Presence of additional operations at former HO storage site will not impact other NCBC operations. Completion of the project will help by restoring the site and allowing it to be used for other purposes.</p>
2. Construction and demolition waste disposal	<p>Incineration process is stand-alone system. Due to possibility of high winds, local codes require the project trailers to be secured to the ground. The temporary foundations will be removed. Contaminated waste produced will be processed by the incinerator system.</p>
a. For details, see Volume III.	

The draft RD&D permit was provided by Region IV to AFESC and EG&G Idaho for review. Comments were submitted to Region IV on June 2, 1986 (Appendix B, Exhibit 5). Because the project fell under RCRA, it was also necessary to submit a notification of hazardous waste activity to obtain a generator identification number. This was done on January 24, 1986 (Appendix B, Exhibit 6).

Initial public notification of the intent to issue an RD&D permit for the full-scale testing was made by an AFESC representative in a briefing on March 18, 1986, to local city mayors from the region. On March 18 and 19, AFESC and EG&G Idaho representatives briefed all base personnel (10 sessions) present at the NCBC, which numbered approximately 1500. During this week, an AFESC representative also briefed the State of Mississippi Bureau of Pollution Control at Jackson, Mississippi.

Formal public notification of intent to issue a permit and a public information meeting for the draft RD&D permit was publicized in a Gulfport newspaper, The Sun Herald, on March 19, 1986 (Appendix C, Exhibit 1.) This notice informed the public that the permit documentation (permit application, draft permit, and draft environmental assessment) were on display at the Gulfport-Harrison County Library for review. The notice stated that the informational meeting would be held in the evening on March 20, 1986, at the Gulfport Community Center. In addition, an article appeared in The Sun Herald discussing the project (Appendix C, Exhibit 2). The informational meeting was conducted as intended with representatives from AFESC, EG&G Idaho, EPA Headquarters, Region IV, and the State of Mississippi in attendance. No negative comments were made at either the NCBC or public briefings.

The public comment period ended on June 30, 1986. Only one comment letter was received, Region IV cancelled the formal hearing for the RD&D permit due to lack of interest. Region IV authorized the RD&D permit (see Volume V) for the project on July 2, 1986, with an effective date of August 4, 1986. The approved permit included changes to the draft permit because of public comment and applicant request during the public hearing period. AFESC did not receive notification from Region IV of any generator identification number for the waste generation activity. The permit granted incineration treatment up to 11,000 cubic yards of soil, miscellaneous combustible (wooden pallets), and noncombustible (concrete/drums) refuse present on the storage area, and residues and equipment resulting from chemical treatment. Duration of the permit was one year, ending August 4, 1987.

Between issuance of the RD&D permit by EPA and start of the verification test burns, additional news articles appeared, some of which drew response from the public. On August 11, 1986, the New Orleans Times Picayune ran a background article on the project (Appendix C, Exhibit 3). This prompted a negatively toned letter to the editor published on September 2, 1986 (Appendix C, Exhibit 4). In response to a Sun Herald headline (August 18, 1986 issue) announcing Jackson County as a possible site for another "death valley" along with Montgomery County, a letter to the editor was published on August 28, 1986, that presented a negative position regarding incinerator burning of dioxins at the NCBC (Appendix C, Exhibit 5). Additional background articles on the NCBC project and site burnup for the verification test burns appeared in The Sun Herald during September and November (Appendix C, Exhibits 6-9). On November 12, 1986, The Sun Herald published an editorial, which acknowledged that there were mixed emotions on the project, but was mostly supportive, closing with a reminder about public safety.

Because of planned connection to the NCBC sewer system, it was necessary to obtain a public-owned treatment works (POTW) permit from the State of Mississippi Bureau of Pollution Control. This was done on

July 16, 1986 (Appendix D, Exhibit 1). The Bureau of Pollution Control responded on September 9, 1986, with a draft final permit showing effluent limitations, schedule of compliance, monitoring requirements, and monitoring reporting dates, and asked for any comments from AFESC (Appendix D, Exhibit 2). AFESC comments were promptly submitted to the Bureau of Pollution Control on September 19, 1986 (Appendix D, Exhibit 3). A revised draft final permit was sent to AFESC by the Bureau of Pollution Control on September 22, 1986 (Appendix D, Exhibit 4). Also enclosed was a Public Notice dated September 30, 1986, which was declared the beginning of a 30-day comment period during which the general public's input and comments were invited. The POTW application was also coordinated by the Bureau of Pollution Control with the Harrison County Waste Water Management District, which expressed no objection to receiving the treated water (Appendix D, Exhibit 5). A 5-year water pollution control permit was issued by the Mississippi Natural Resources Permit Board for the project on October 31, 1986 (Appendix D, Exhibit 6.)

7. Delisting Process

According to the EPA regulations described in 40 CFR 260.20, waste containing 2,3,7,8 TCDD or 2,3,7,8 TCDF is classified as an F027 waste. On November 7, 1986, EPA Office of Solid Waste promulgated regulations that effectively banned the land disposal of waste containing dioxins in excess of 1.0 ppb (Reference 22). The regulations permitted disposal of dioxin-containing waste in approved landfills if the dioxin concentration was less than 1.0 ppb; however at the time of project commencement, there were no approved landfills in the United States accepting dioxin-contaminated waste. This effectively meant that disposal of dioxin-containing waste required processing. However, when such a waste is processed in an EPA approved incinerator, the resulting waste is still considered hazardous and is defined as an F028 waste.

Because the F028 waste is still considered hazardous, it must either be disposed as hazardous waste in an approved Subtitle C landfill or be excluded as a hazardous waste, or "delisted." Delisting is a

procedure by which a waste generator may petition the EPA to review applicable data that could be used to determine if a waste meets the regulatory definitions of a hazardous waste. A petition mechanism (to EPA Headquarters) is described in 40 CFR 260.20 and 260.22, which allows persons to demonstrate that a specific waste from a particular site or generating facility should not be regulated as a hazardous waste under 40 CFR 261. To be excluded, petitioners must show that the waste does not meet any of the listed criteria and must also demonstrate that the waste does not exhibit any of the hazardous waste characteristics and does not contain any other toxicants at hazardous levels (Reference 23). If the EPA determines that the waste is no longer hazardous, they will remove that particular waste from their list of hazardous wastes, hence the name, "delisting."

Once an F028 waste is delisted, it may be placed in a Subtitle D type landfill (e.g., a permitted municipal solid waste landfill) or it may be placed back upon the original site. The most economical option for the process ash appeared to be delisting followed by onsite disposal. Therefore, the delisting option was pursued.

As with most regulatory petitions, however, the delisting process undergoes a very long and detailed review cycle. At the time of project initiation, the EPA Office of Solid Waste expected the delisting process to take up to two years and they would not grant "up front delisting" (i.e., delisting of the waste prior to processing and analysis of the processed soil). Furthermore, the delisting authority, which differs from the RD&D permitting authority, could influence the sampling and analysis planning for the Verification Test Burns. Therefore, AFESC and EG&G Idaho project personnel obtained guidance from EPA early in the project to improve the possibility of delisting petition approval when submitted later.

A draft delisting petition (along with a copy of the RD&D permit application) was submitted on January 22, 1986, to the EPA's Office of Solid Waste (OSW) in Washington, D.C. (Appendix E, Exhibit 1). Included was a list of constituents possibly present in the untreated soil at the

former HO storage site. The recommended analytical methods and associated detection limits for each constituent were also listed. Because the revised RD&D application included a revised sampling and analysis matrix plan, a copy of this plan was transmitted to EPA/OSW seeking verification that the revised plan was acceptable for the purpose of pursuing delisting (Appendix E, Exhibit 2). OSW did not respond during the period of the RD&D application review by EPA.

EPA/OSW responded to the June request on September 11, 1986 (Appendix E, Exhibit 3). The EPA letter:

1. Identified PCDD/PCDF congeners, chlorinated benzenes, and chlorinated phenols to be on the analysis list.
2. Recommended a list of only 9 metals; whereas, the EG&G Idaho list showed 14 metals.
3. Added three polycyclic aromatic hydrocarbons not on the submitted list.
4. Added 2,4-D and 2,4,5-T to the analysis list.
5. Deleted coal tar and creosote from the analysis list.

A meeting was held with OSW in Washington, D.C., on September 19, 1986, to clarify certain details regarding their letter. A representative from Versar, Inc., the organization performing the verification sampling for the project, also attended. Versar, Inc. transmitted a modified sampling and analysis matrix plan to EPA/OSW on October 15, 1986 (Appendix E, Exhibit 4). This plan included all analyses requested by OSW and several

additional analyses to ensure that comprehensive analytical data would be available. The letter also included discussion about methods to achieve low detection limits for PCDDs/PCDFs and organics. OSW confirmed that the modified sampling and analysis matrix plan was satisfactory on December 12, 1986, but added that cyanide/sulfide testing must be included (Appendix E, Exhibit 5).

As an additional part of the advance delisting process, EG&G Idaho performed a vertical horizontal spread (VHS) model analysis to satisfy proposed requirements shown in Federal Register for November 27, 1985 (Reference 24). The VHS model analyzes the transport of toxicants from disposal sites to nearby receptors and was based on formulation and available data applicable at the time. EG&G Idaho provided a copy of the analysis to EPA/OSW for review and comment (Appendix E, Exhibit 6).

C. SCOPE/APPROACH

The scope of this report is to document the results of the ENSCO MP-2000 incinerator process to treat NCBC soil contaminated by PCDDs and PCDFs. The approach was to conduct a field demonstration with a full-scale unit at the NCBC site. A suitable quantity of contaminated soil (about 26 tons) was excavated and treated by the incinerator process. The incinerator operating parameters were varied to demonstrate treatment acceptability and repeatability. Versar performed all sampling activities. IT Analytical Services of Knoxville, Tennessee, provided analytical laboratory analyses. EG&G Idaho provided overall project management and performed verification and validation of analytical data. An AFESC representative acted as a liaison with the involved federal and state agencies.

This report is contained in five parts. Part 1 documents the results of the MWP-2000 incinerator system verification test burns at NCBC. The remaining parts consist of a set of appendixes. Part 2 contains Appendixes A-J; Part 3 contains Appendixes K-S; Part 4 contains Appendix T, and Part 5 contains Appendixes U-W. For the convenience of the reader, a complete list of appendixes is contained in Part 1.

SECTION II

TEST EQUIPMENT TECHNOLOGY

This section provides a brief description of the MWP-2000 incinerator system components and operation. A more detailed description can be found in Appendix F.

A. GENERAL DESCRIPTION

The ENSCO incinerator system (Mobile Waste Processor-MWP-2000) was designed and fabricated by ENSCO at the White Bluff, Tennessee, manufacturing facility. The MWP-2000 incinerator is a modular system designed to destroy and detoxify solid, semisolid, and/or liquid wastes. Most of the components of the system are installed on flatbed trailers, platforms, or skids to facilitate the movement of the system from location to location in order to perform onsite cleanup of contaminated sites.

Figure 5 shows an overall view of the MWP-2000 incinerator system as it was installed at the NCBC site. Figure 6 is a system flow schematic. Principal components of the unit are:

- Waste feed system
- Rotary kiln with outlet cyclones
- Secondary combustion chamber (SCC)
- Air pollution control train consisting of
 - Effluent neutralization unit

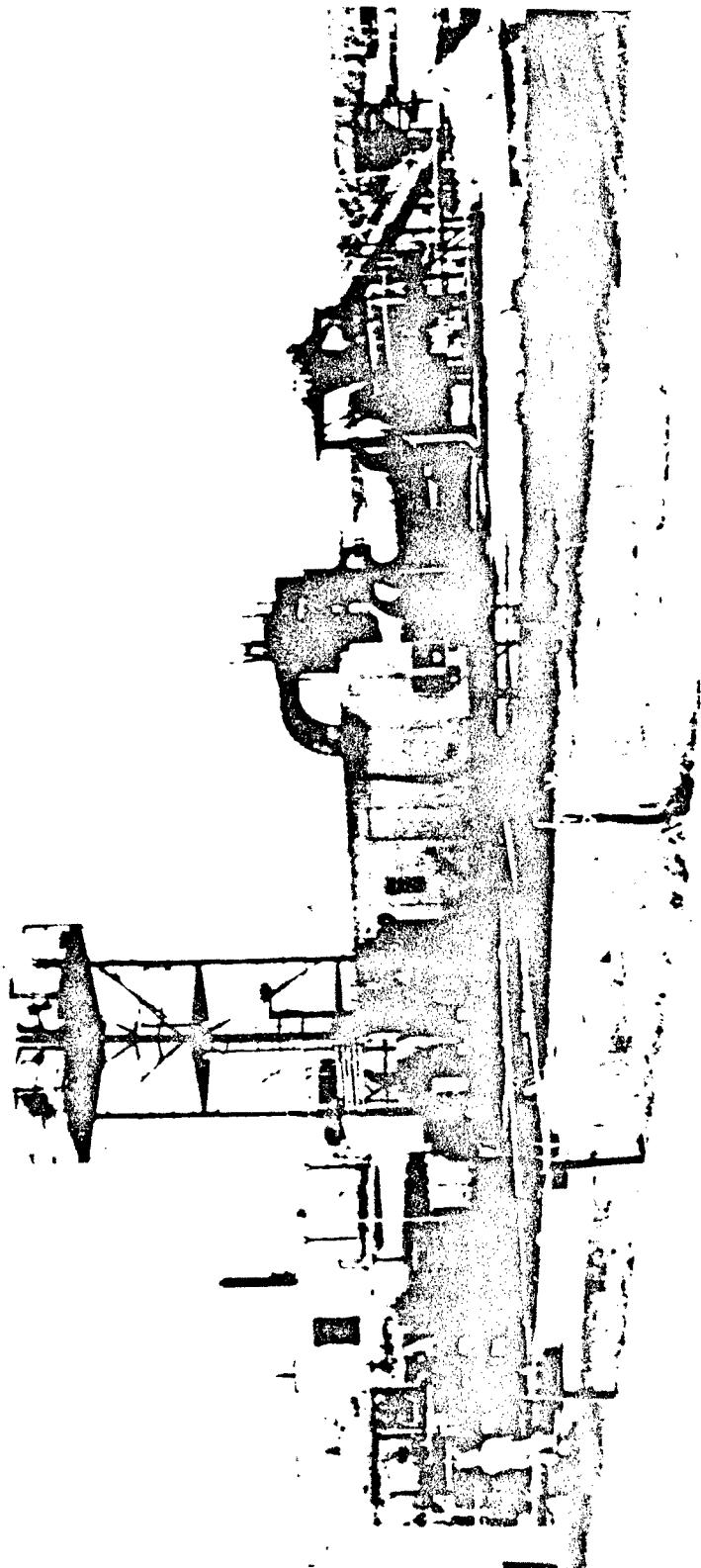


Figure 5. Overall view of MWP-2000 incinerator system.

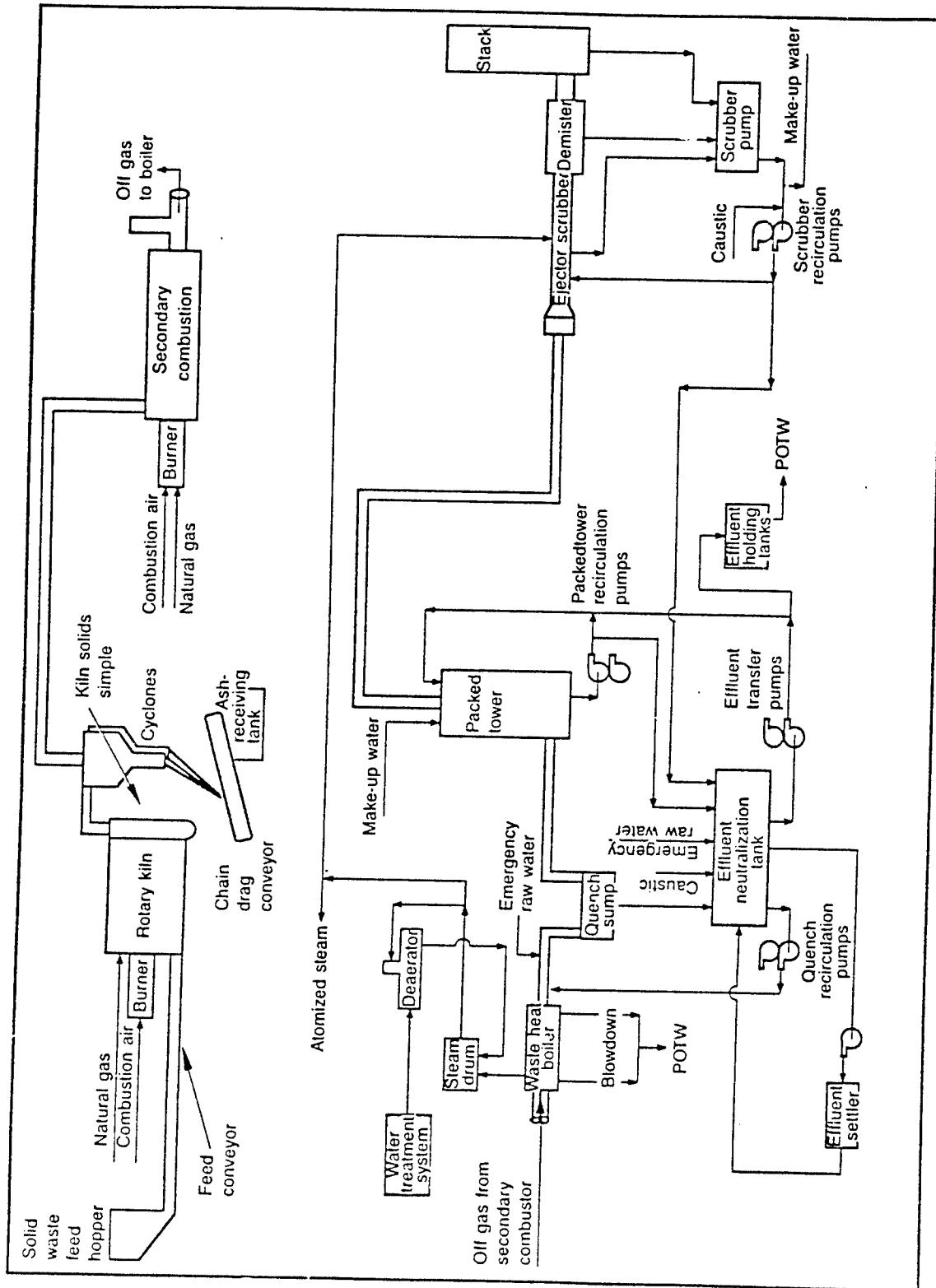


Figure 6. Schematic flow diagram of MWP-2000 incinerator system.

- Packed tower
- Ejector scrubber, demister, and stack.

The auxiliary components of the unit are:

- Waste heat boiler and steam drum
- Boiler water treatment unit
- Ash removal unit
- Effluent setting unit
- Effluent holding tanks.

B. PROCESS DESCRIPTION

1. Feed

After soil has been excavated, it is stockpiled near the incinerator. A bucket loader then transfers the soil to a weigh hopper/shredder unit (Figure 7). The soil is then weighed and shredded into small pieces, which then drop onto a covered feed conveyor that transfers the soil to the feed hopper (Figure 8).

Once the soil falls into the feed hopper, a rotary auger moves the soil into the rotary kiln (Figure 9). Figure 10 shows the 10-inch diameter auger in process of feeding soil.

2. Primary Incineration

The rotary kiln is primarily designed to burn or detoxify hazardous waste. Detoxification occurs by thermal desorption of organics

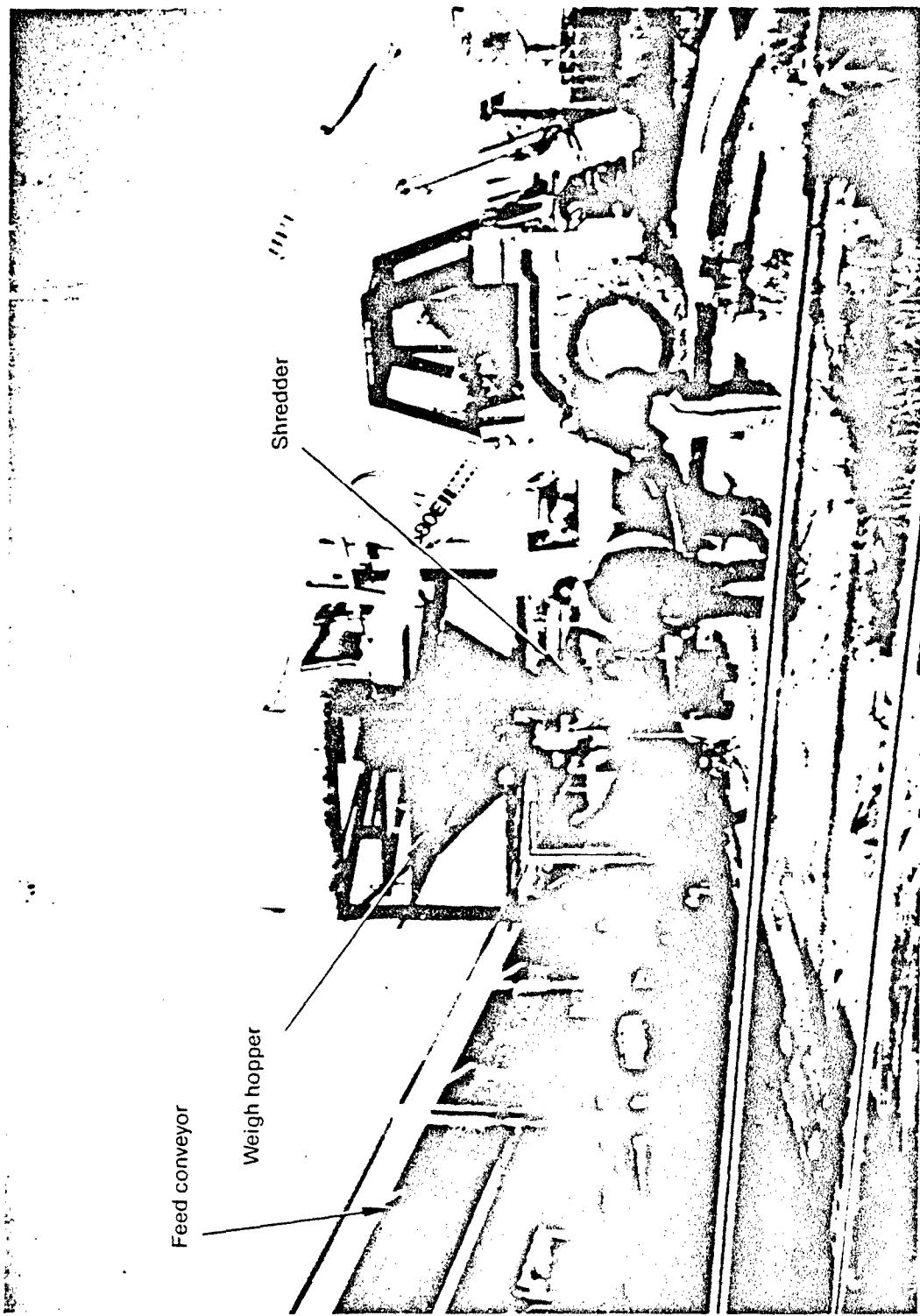


Figure 7. View of weigh hopper, shredder, and covered conveyor.

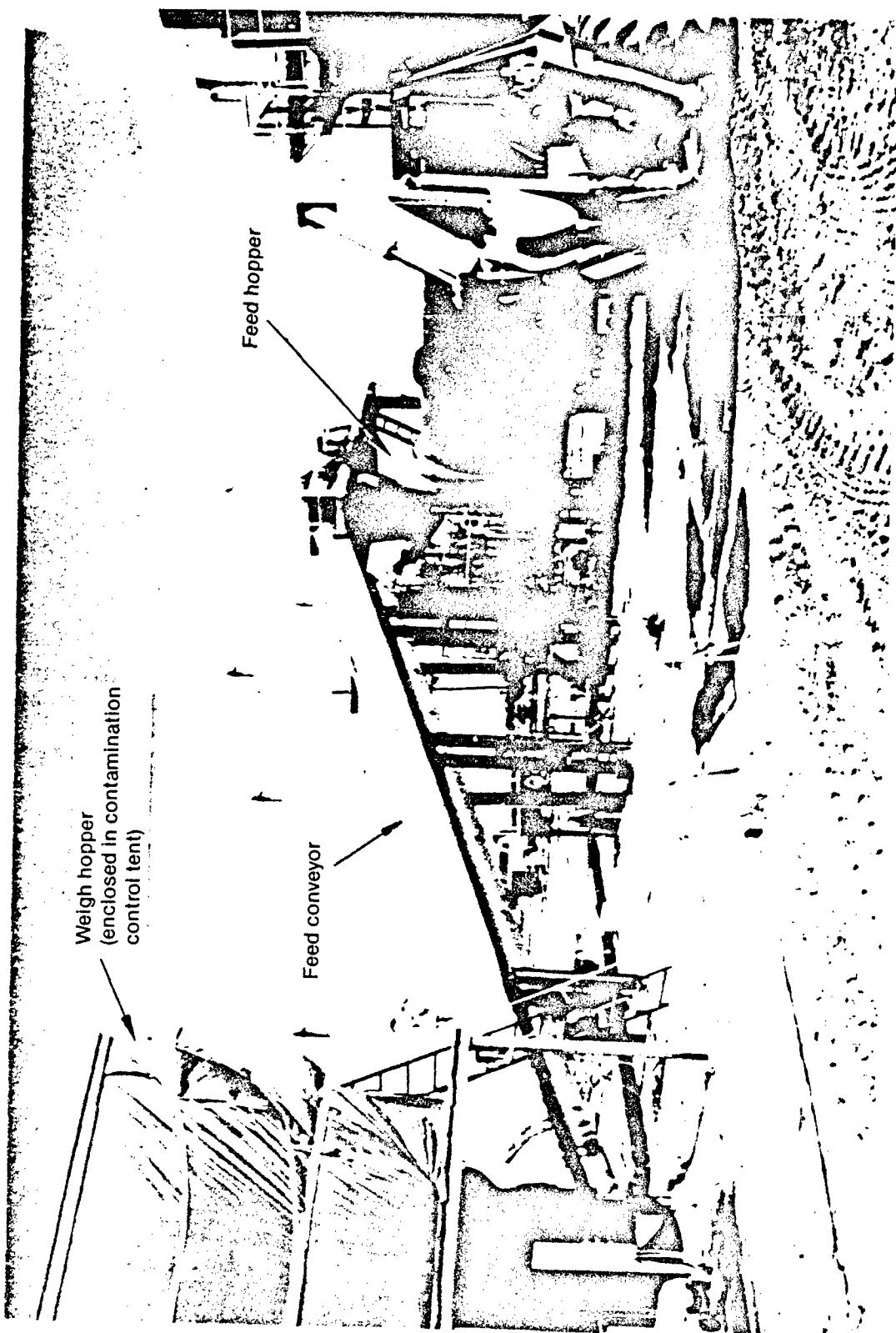


Figure 8. View of covered conveyor and feed hopper.

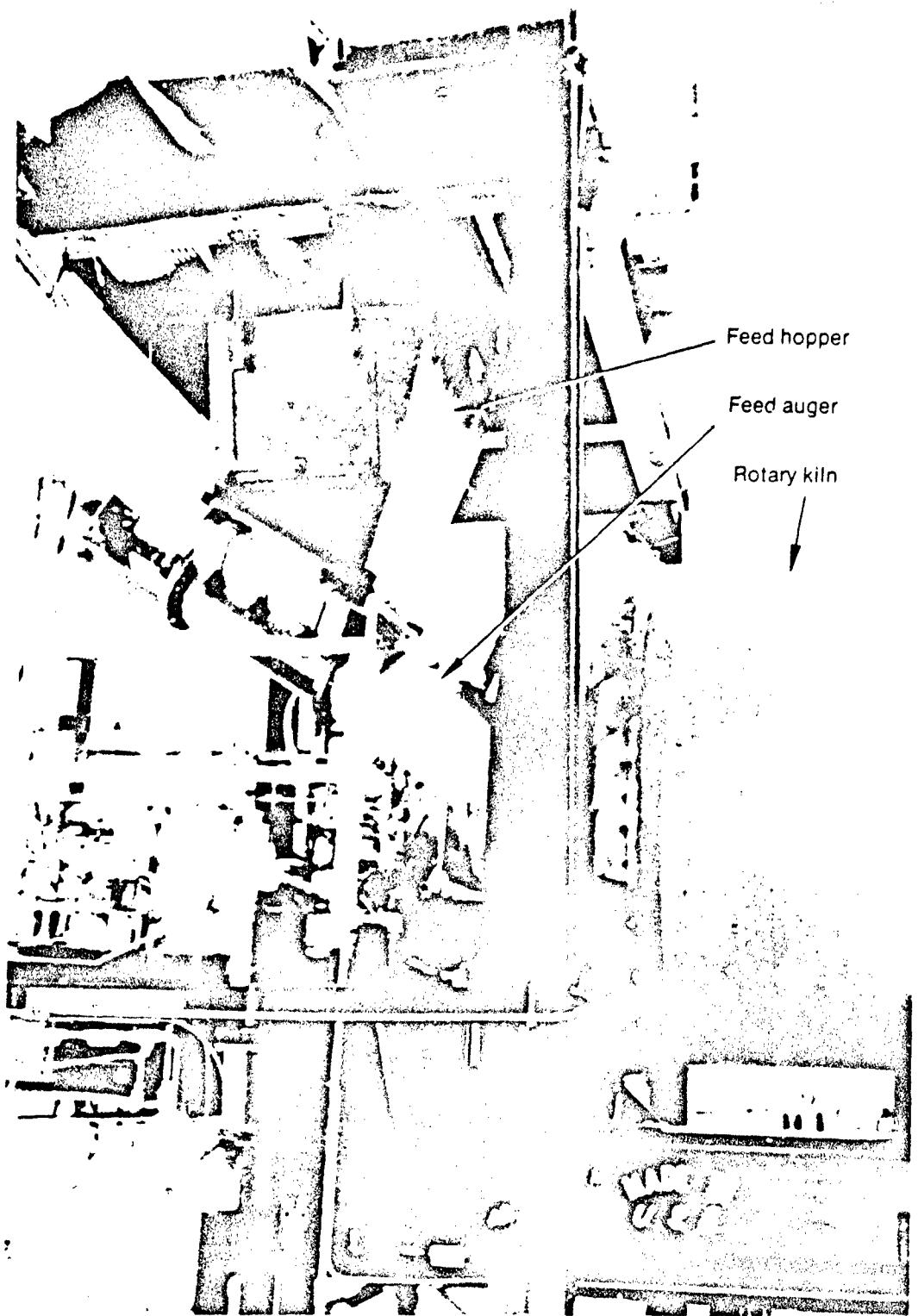


Figure 9. External view of feed hopper bottom and auger feed to kiln.



Figure 10. View of rotary auger inside feed hopper.

from the solid waste. Because of the high temperatures, however, the kiln will combust and destroy some of those desorbed organics. Additionally, waste water and other liquid materials can be processed by injection through nozzles located near the burner. This option, however, was not used during this demonstration project.

The rotary kiln is shown in Figure 11. The kiln is approximately 30 feet long and sits on top of a flatbed tractor trailer. The kiln is inclined at approximately 2 degrees and is rotated by a hydraulically powered gear trunnion mechanism (Figure 12).

The kiln burner is rated at 14 million Btu/hr and can use a variety of fuels such as fuel oil, propane, or natural gas; this project used natural gas. The outlet gas temperatures typically range from 1350°F to 1800°F. The solids residence time within the kiln varies from 20 to 40 minutes, depending upon the mass feed rate.

3. Ash Collection

At the gas outlet of the kiln, the solids fall into an ash quench while the gases rise up and flow into the cyclone particle separators. The ash quench is a rectangular water tank into which the processed soil falls. The ash quench and cyclones are shown in Figure 13.

At the bottom of the ash quench is an ash drag conveyor that removes the process ash and places it into an ash bin (Figure 14). During the verification tests burns, a rolloff box, also shown in Figure 14, was used. The ash quench also serves as a seal between the process gases and the outside environment.

4. Gas Stream Particulate Separation

The hot process gases flow from the kiln upward to the cyclone separators, which remove the heavy particulate from the gas stream. The

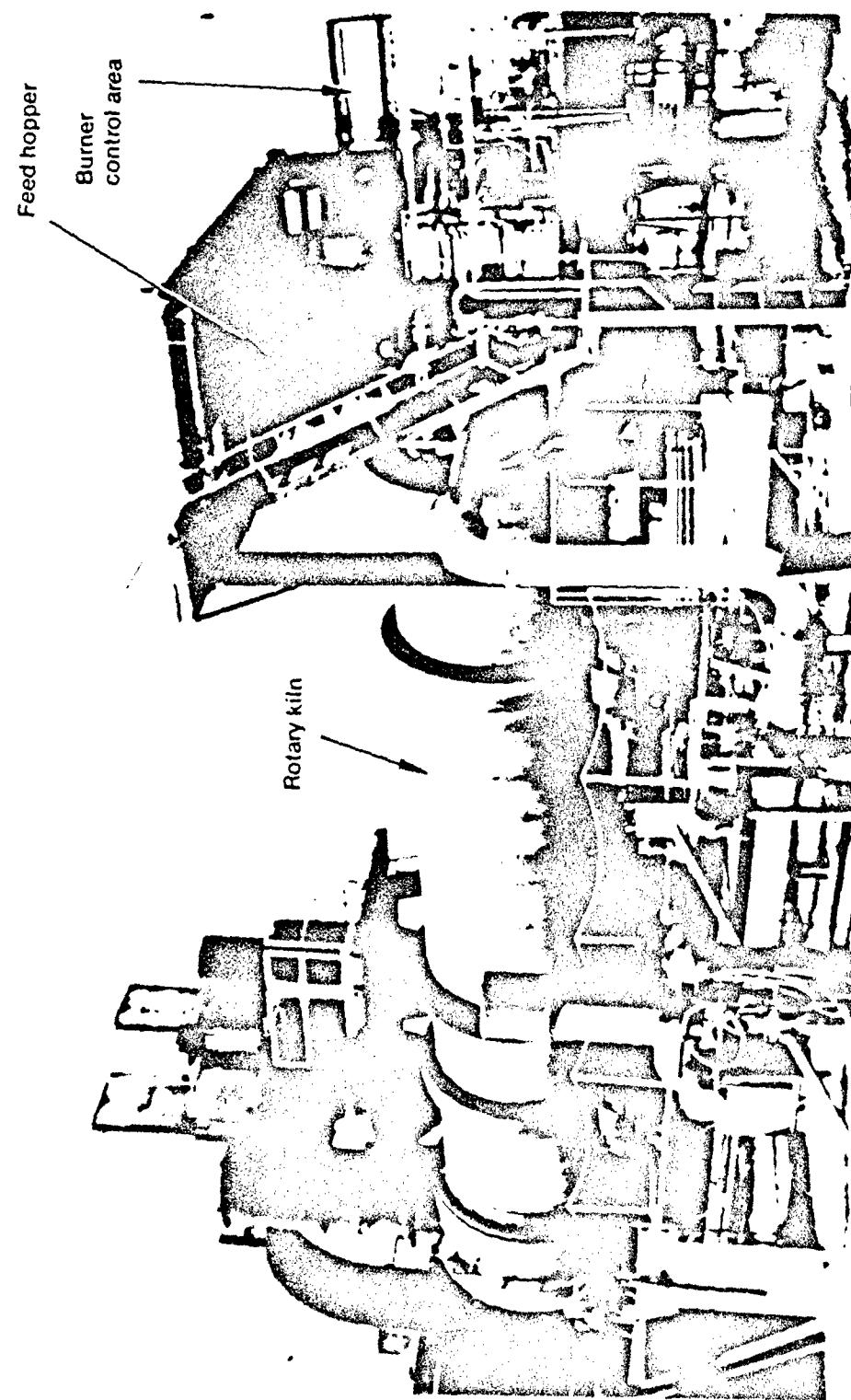


Figure 11. View of trailer-mounted rotary kiln.



Figure 12. View of kiln rotary drive mechanism and trunnion supports.

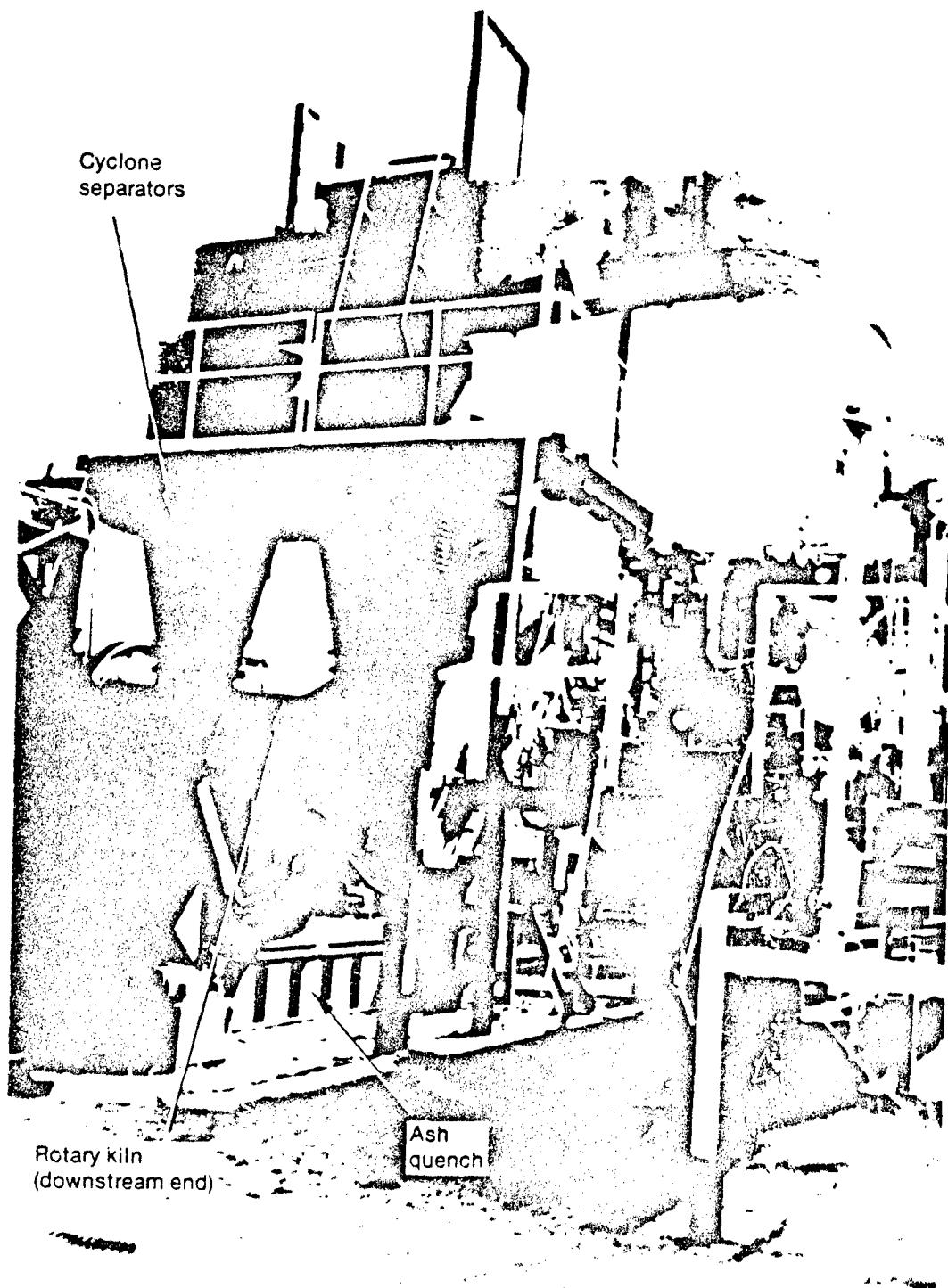


Figure 13. View of cyclones and ash quench.

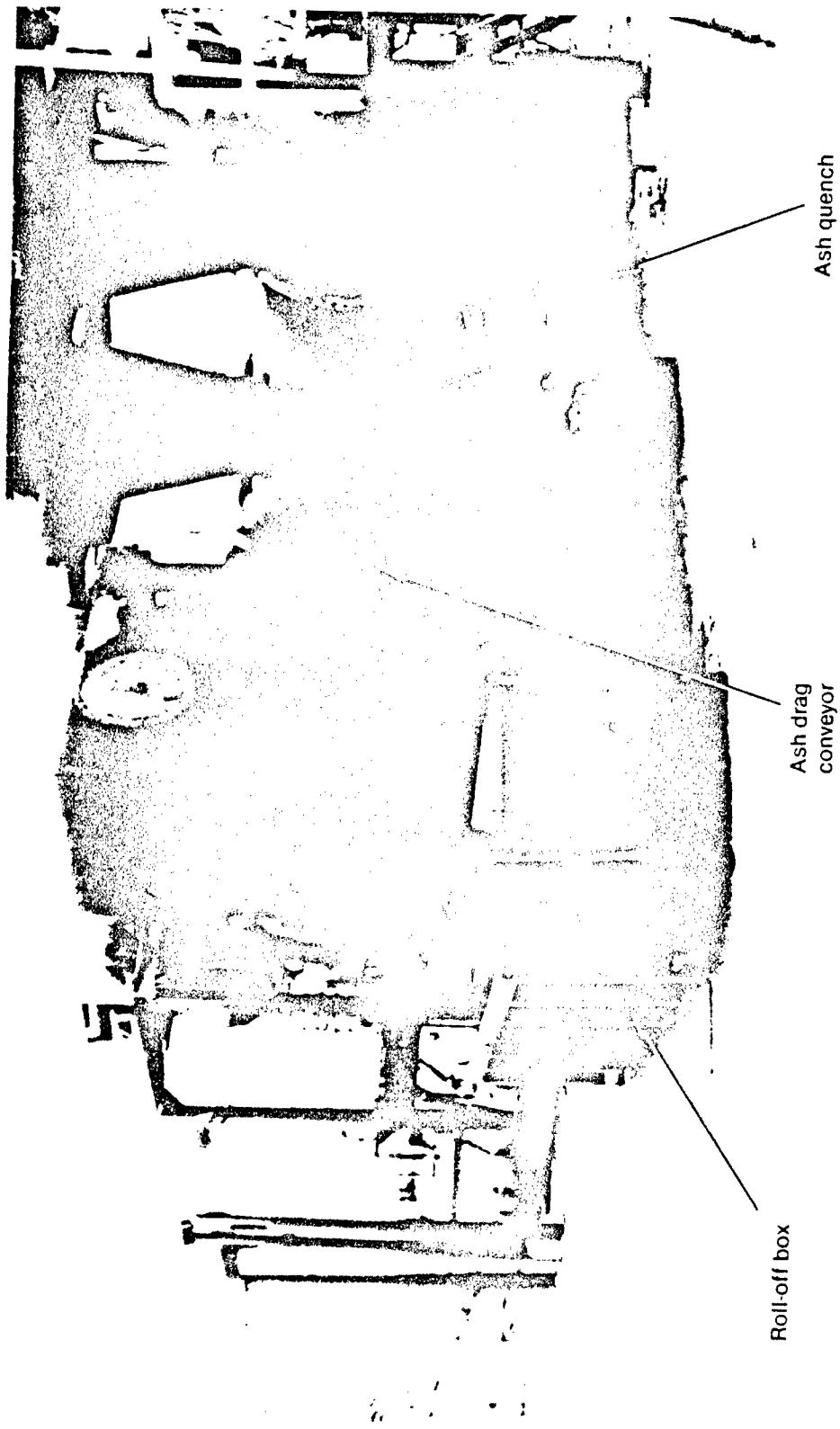


Figure 14. View of ash drag and roll-off box for ash collection.

removed particulate falls down into the ash quench. Although the incinerator has two cyclones in parallel flow paths, only one cyclone was used for this project (see Section VI.E.2 for further discussion).

5. Secondary Combustion

The process gases then leave the cyclone and flow into the secondary combustion chamber (SCC), which raises the temperature of the process gas to 2150°F. This high temperature combusts any remaining organics in the off gas that were not combusted in the kiln. The SCC is shown in Figure 15. The SCC is approximately 40 feet long and sits on top of a flatbed tractor trailer.

The SCC is equipped with a vortex burner capable of producing approximately 24 million Btu/hr by burning natural gas. The burner can use fuel oil, or propane in addition to natural gas; however, those fuels were not used during the demonstration project. Similar to the kiln, the SCC can burn liquid organics or contaminated water by direct injection of the liquid into the burner flame. Liquid waste was not processed during this demonstration project.

6. Gas and Liquid Effluent Waste Stream Control

After leaving the SCC, the gases flow through a fire tube boiler that is designed to produce 250 psig steam by recovering heat from the off-gases. The waste heat boiler and its steam drum are shown in Figure 16. The steam produced in the boiler is used primarily for the ejector scrubber, which is discussed below.

In order to prevent molten and vaporous silica from the processed soil from glassifying onto the inside of the boiler tubes, water spray nozzles were installed between the SCC and the waste heat boiler. The injected water condenses the molten and vaporous silica so that the silica behaves as a particulate, rather than as a gas, and, thus, not plate out onto the boiler tubes.

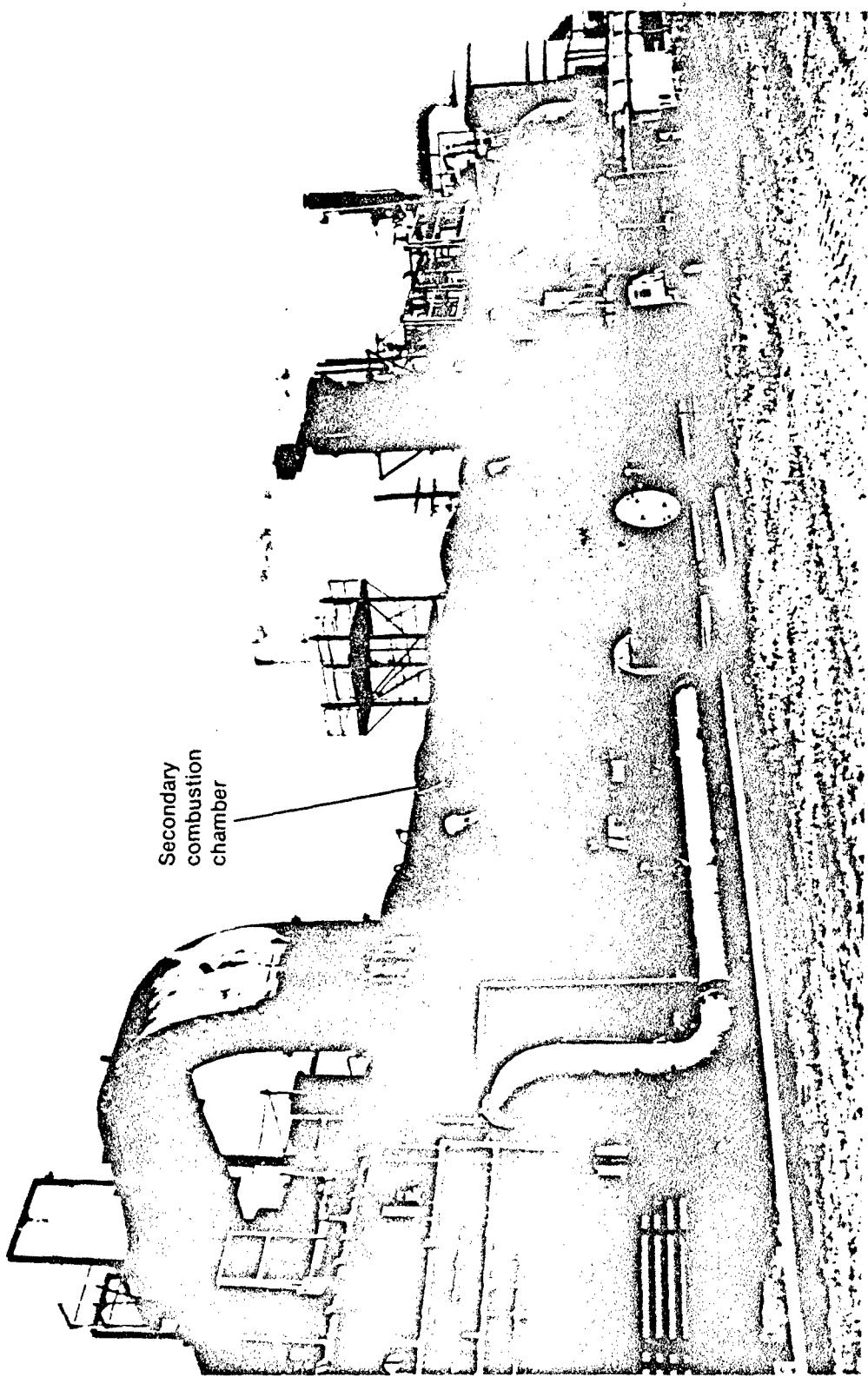


Figure 15. View of trailer-mounted secondary combustion chamber.

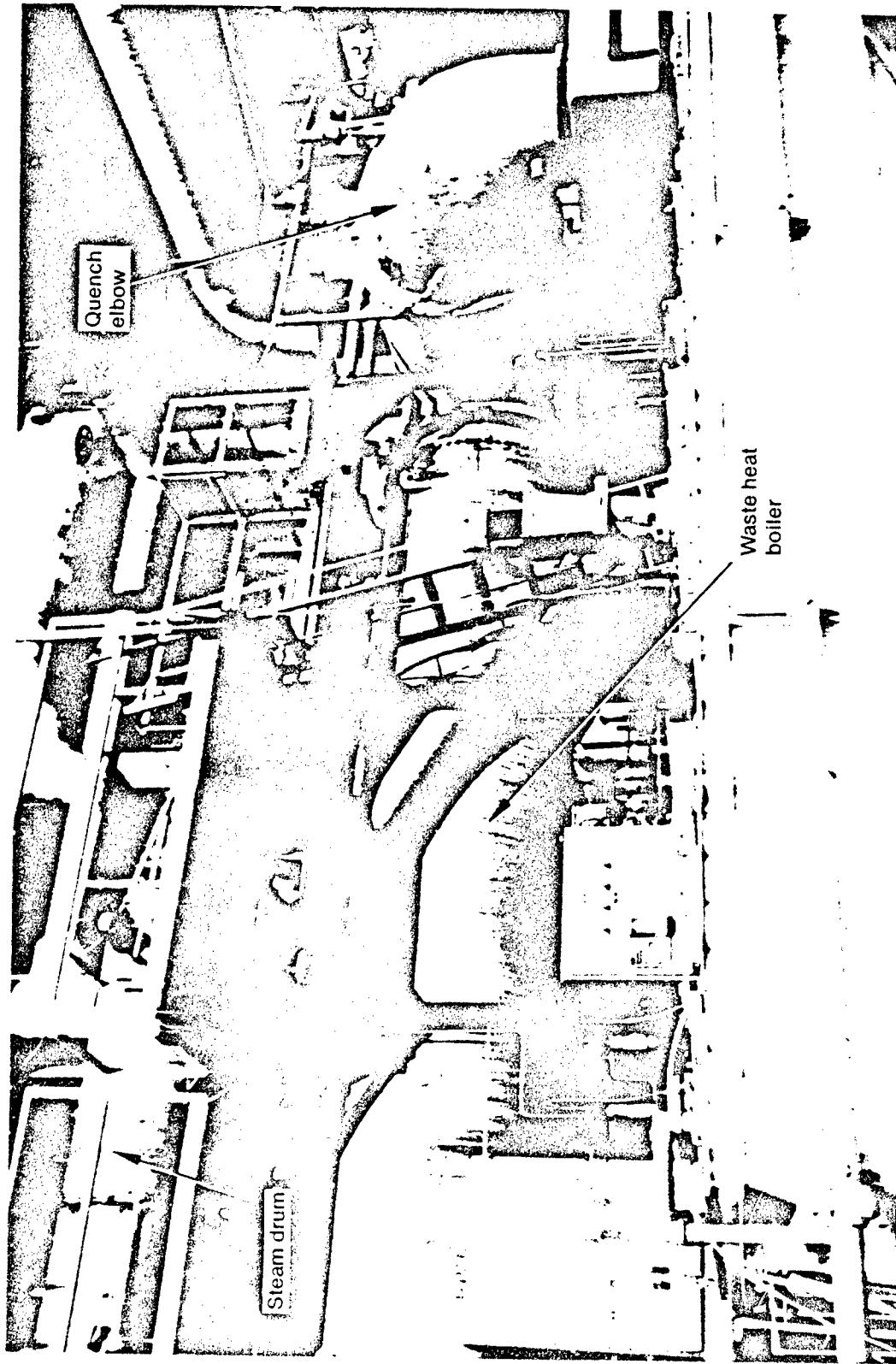


Figure 16. View of waste boiler and steam drum.

After the gases leave the boiler, they enter the quench elbow, which is the first of a series of devices that control effluent gas emissions. The quench elbow, shown to the right of the waste heat boiler in Figure 16, is designed to cool the off gas by direct water injection. The injected water cools the gases to approximately 180°F thus allowing the use of fiberglass-reinforced plastic for all downstream gas ductwork. Additionally, the quench elbow removes some of the acid gases.

The excess water from the quench elbow is collected in the effluent neutralization tank (ENT), which is in front of the quench elbow and packed tower shown in Figure 17. The ENT serves as the central collection point for all of the scrubber water used. The water collected in the ENT is used in a variety of scrubber applications. Caustic (e.g., NaOH) is added to increase the acid gas scrubbing efficiencies of the scrubbing water.

After the gases are cooled, they flow upwards through the packed tower, which is a counter-current flow contract absorber (Figure 18). Water is sprayed in the tower at the top and flows downward over plastic packing material, which maximizes its contact with the upward moving gases.

Upon leaving the packed tower, the gases flow into the ejector scrubber. The ejector scrubber (Figure 19) serves two primary purposes: (a) to remove the fine particulate from the off gases, and (b) to provide the motive force to draw the gases through the entire incinerator system. The ejector scrubber operates by injecting high-pressure steam into the annular region of the ejector scrubber. The steam acts as the motive fluid in an ejector pump and agglomerates the fine particles in the venturi section of the jet pump.

After leaving the ejector scrubber, the gases flow through a demister, also shown in Figure 19. The demister removes the condensate from the jet scrubber along with the agglomerated fine particulate captured in the condensate. The condensate water and particulate are

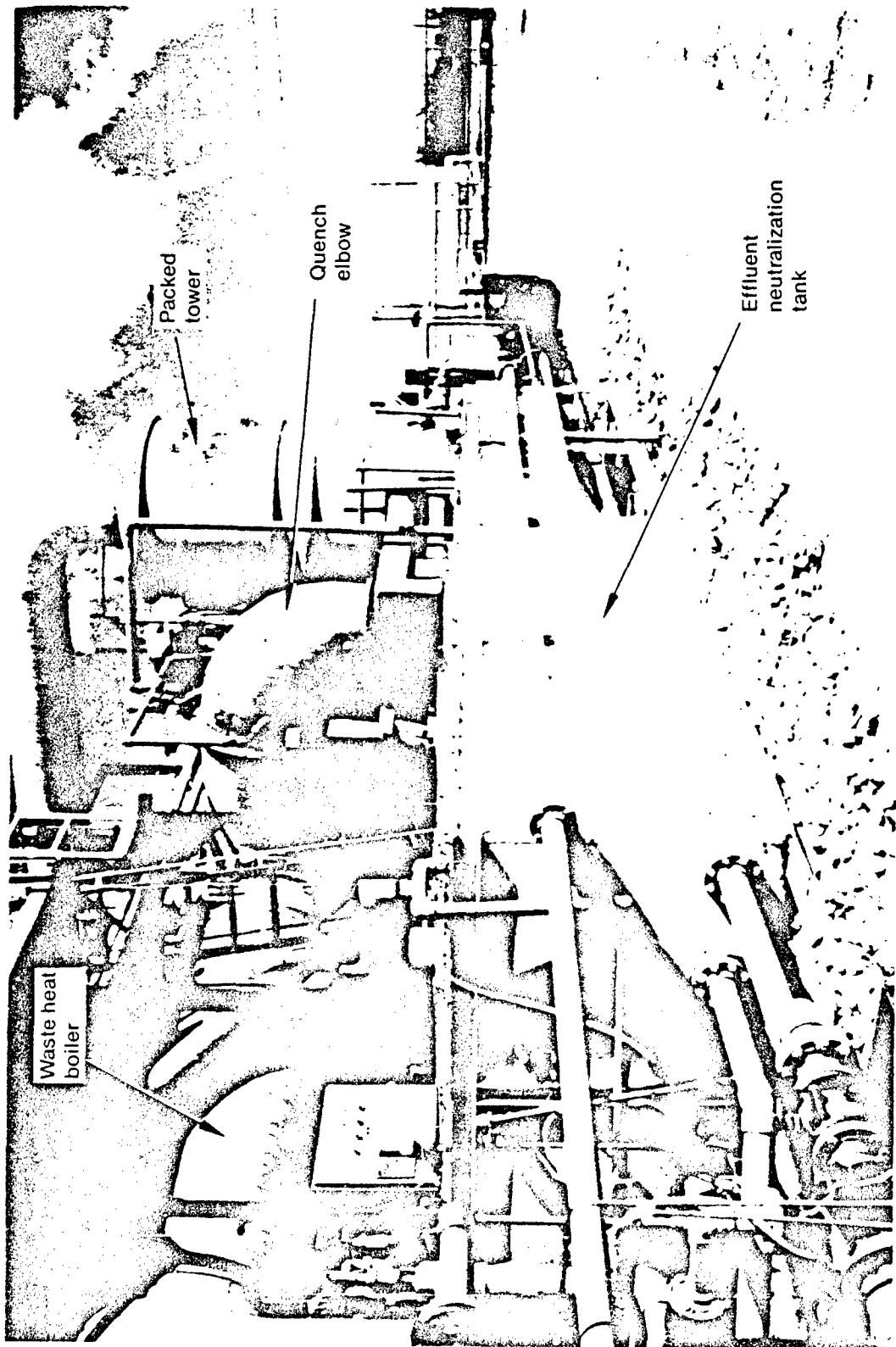


Figure 17. View of effluent neutralization tank with quench elbow and packed tower (background).

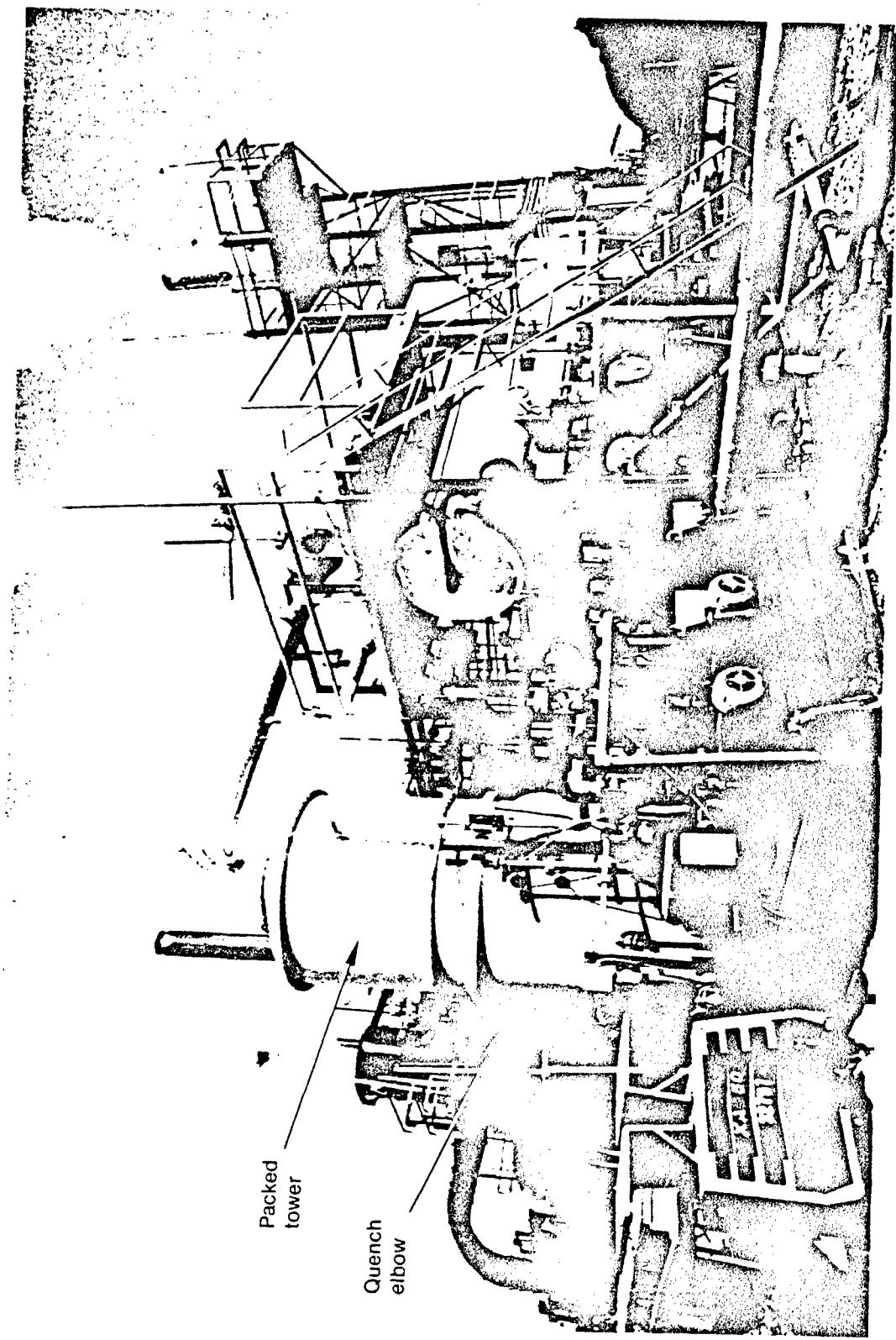


Figure 18. View of skid-mounted packed tower.

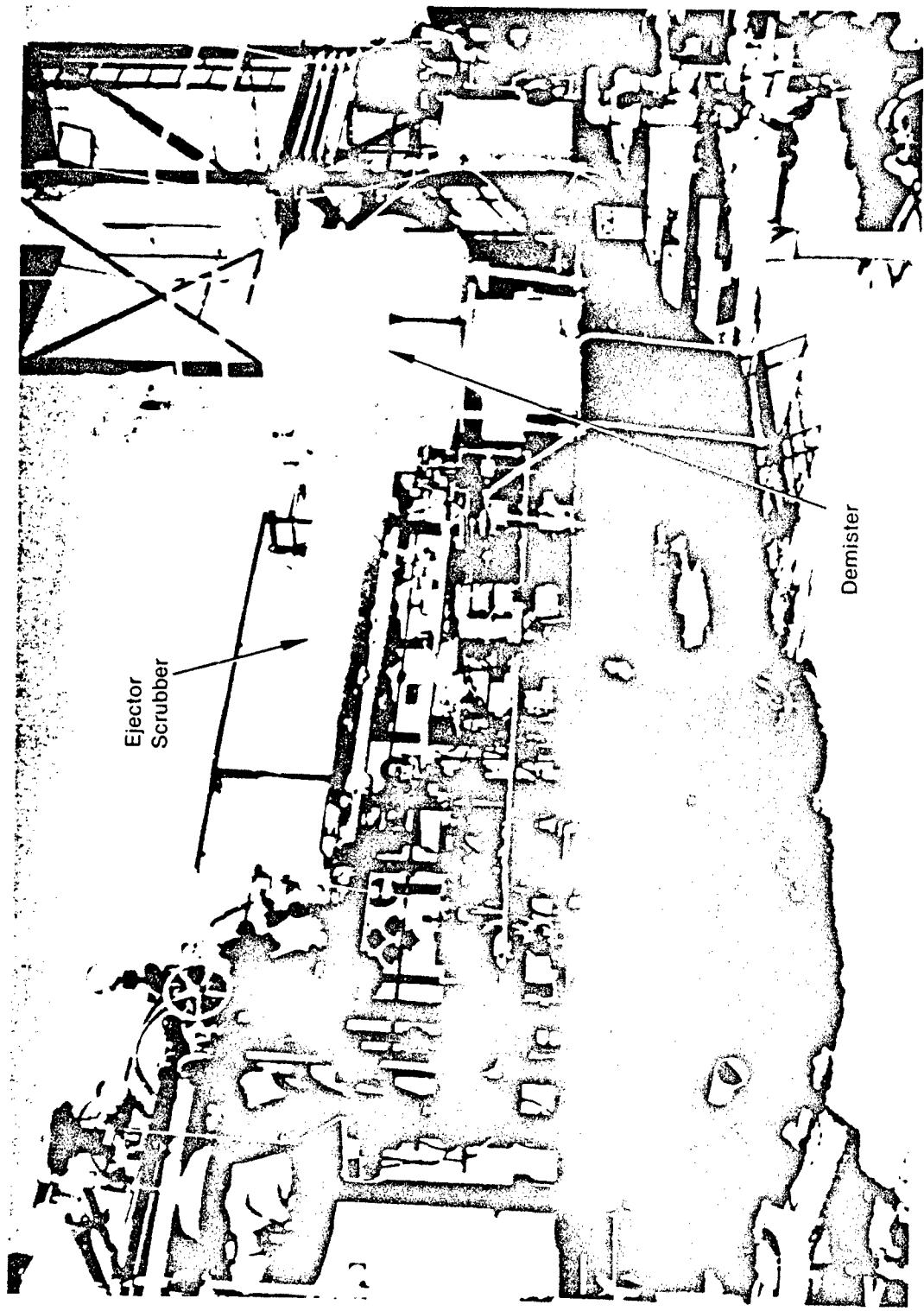


Figure 19. View of trailer-mounted ejector scrubber and demister.

pumped back to the effluent neutralization tank for recycling. The combustion gases and steam from the jet pump are then exhausted through the 40-foot tall stack, as shown in Figure 20 (see also Figure 5). The ejector scrubber, demister, and stack are mounted on a flatbed tractor trailer; however, the stack is installed at the field site.

C. PROCESS MONITORING AND CONTROL

The incineration process is remotely monitored and controlled from an operator's panel located in a mobile control room trailer. This panel provides the operator with indications of process system parameters and those manual controls necessary to adjust system variables to required operating conditions. This includes numerical and status light indicators, switches, video monitors, and computer monitor (many of which are shown in Figure 21).

Central to the control process is monitoring by a personal computer-based data acquisition system (DAS). The DAS collects data from electronic instruments which include a variety of thermocouples, pressure transducers, and level indicators. A complete list of the instruments is provided in Appendix F. In addition, the stack gas emissions are continuously monitored for carbon monoxide, carbon dioxide, and excess oxygen content. The combustion efficiency being achieved by the MWP-2000 incinerator system is continually calculated by the DAS from readings from the carbon monoxide and carbon dioxide monitors.

The DAS also is able to automatically stop waste feed if certain operational parameters fall outside of the EPA permit specifications or if the flame to the kiln or SCC fails. Details of the automatic waste feed shutoff (AWFSO) system are provided in Appendix F.

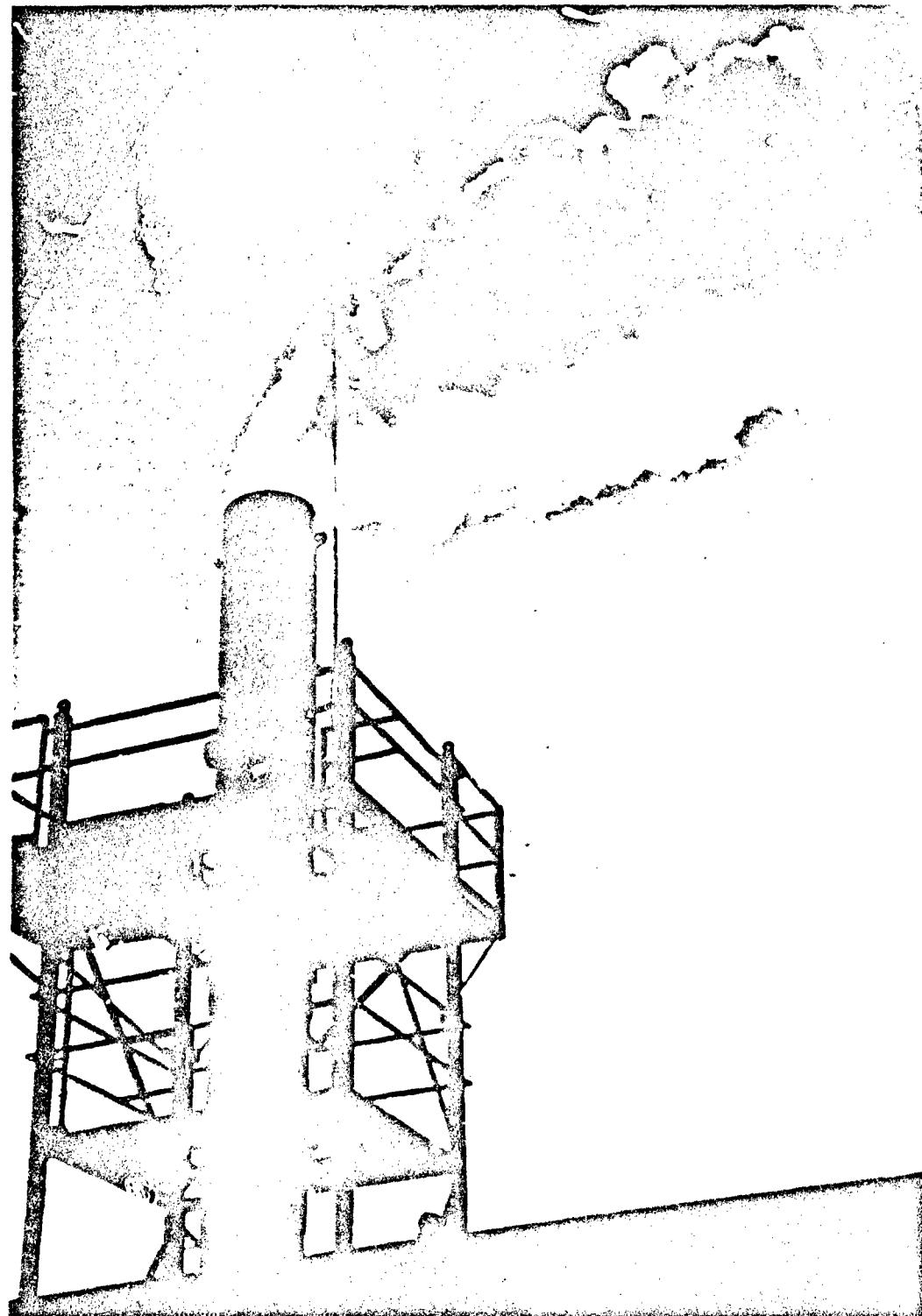


Figure 20. View of incinerator stack.

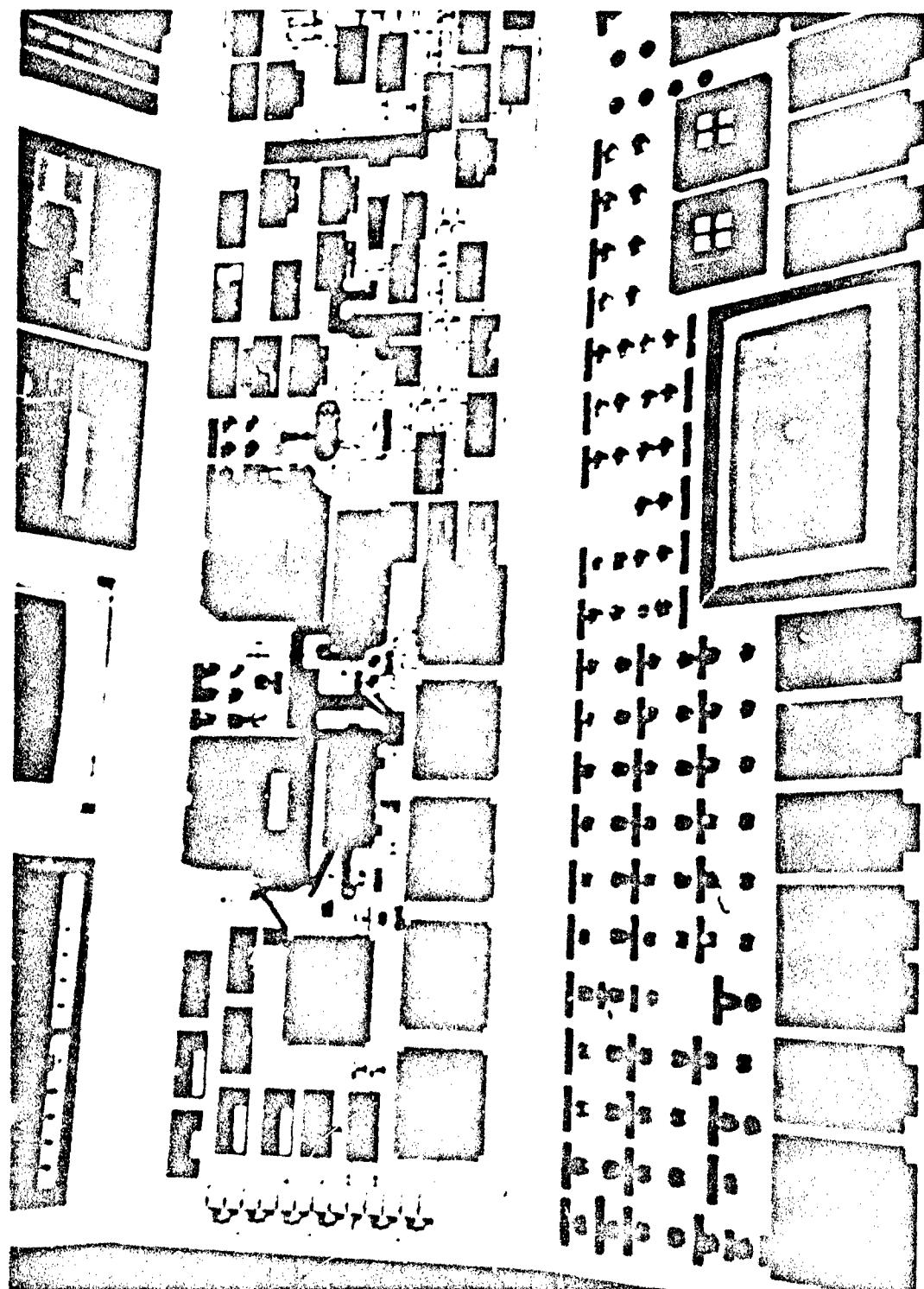


Figure 21. View of incinerator operator's control panel.

SECTION III

FIELD TEST METHODS AND APPROACH

A. TEST PLAN

Significant planning activities were completed to ensure safe and timely accomplishment of the project goals. These planning activities included:

- Test plan for verification test burns (Appendix G)
- Health and safety plan (Appendix H)
- Emergency and contingency plan (Appendix I)
- Spill prevention control and countermeasures plan (Appendix J)
- Sampling plan (Appendix K).

ENSCO prepared the health and safety plan and submitted it to EG&G Idaho for review. Versar prepared the sampling plan, which included the supporting quality assurance/quality control (QA/QC) plan, and submitted it to EG&G Idaho for review. EG&G Idaho prepared the test plan and spill prevention control and countermeasures plan and jointly prepared the emergency and contingency plan with ENSCO. All documents were submitted to the AFESC Project Representative for review before the verification test burns.

The overall plan for the MWP-2000 verification test burns included: (1) incinerator setup and checkout, (2) soil preparation and handling, and (3) incinerator operation. Approximately 270 tons of clean and contaminated soil were planned to be processed during the verification test burns. EG&G Idaho/AFESC project management designated the soil excavation locations for contaminated soil based on results of surface

soil sampling (Reference 16). Soil with the highest known contamination levels was used to best demonstrate the capabilities of the treatment technology. Details of the soil preparation are presented in Section IV.B.

The goals of the verification test burns were (Appendix G):

- to determine if the MWP-2000 can reduce the concentrations of tetra-, penta-, and hexachlorodibenzo-p-dioxins and the tetra-, penta-, and hexachlorodibenzo furans to levels less than 1 ppb. Additionally, it is desirable to reduce the level of those chemicals listed in Appendix A of the RD&D Permit application (Reference 15) to levels acceptable for "delisting" of the treated soil under the Resource Conservation and Recovery Act.
- to verify whether the incinerator is capable of processing the cement-stabilized soil without producing additional listed or characteristic hazardous waste.
- to ensure that the operation of the incinerator does not cause any adverse effects to human health or the environment.

One or more tests at each of the following feed rates were planned to provide data for an operating range within the MWP-2000 capacity: (1) 3 ton/hr, (2) 4 ton/hr, and (3) 4.5-5.0 ton/hr. Gas outlet temperatures for the rotary kiln and the secondary combustion chamber were planned at 1600-1800°F and 2150°F, respectively. The planned approach was to reach operating conditions and operate with clean soil (approximately 240 tons) for 3 days continuous operation and then follow with individual contaminated soil test runs. Periods of standby operation (no soil being fed) were phased between the initial clean soil checkout and the different tests in order to provide distinct identification for process sampling. Table 3 lists the planned operating conditions and parameters to be monitored during the verification test burns. Ranges or operating setpoints are shown, with those parameters specified in the RD&D permit (Volume IV) identified.

Table 3. Planned operating conditions and monitored parameters for verification test burns

<u>Parameter</u>	<u>Normal Range or Setpoint</u>
Nominal soil feed rate	Variable 3-5 ton/hr
Soil residence time	Variable 20-60 min
Kiln combustion air flow rate	120 lbs/min
Kiln outlet gas temperature ^a	1600-1800°F
Kiln pressure ^a	negative pressure
Secondary combustor combustion air flow rate	300 lbs/min
Secondary combustor outlet gas temperature ^a	2150°F minimum
Secondary combustor pressure	negative
Outlet soil temperature	1600-1800°F
Gas residence time in secondary combustor ^a	1-2 seconds
Combustion efficiency ^a	99%
Boiler outlet gas temperature	450°F
Boiler steam pressure	220-240 psig
Steam drum level	40-60%
Boiler makeup water flow rate	20-30 gpm
Quencher recirculation water flow rate	100 gpm
Quencher makeup water flow rate	15 gpm
Quencher outlet gas temperature	190°F
Packed tower recirculation water flow ^a	170 gpm
Packed tower makeup water flow rate	15 gpm
Scrubber recirculation water flow rate ^a	40 gpm
Stack gas oxygen ^a	3% minimum
Stack gas CO ^a	50 ppm

Table 3. (continued)

<u>Parameter</u>	<u>Normal Range or Setpoint</u>
Stack gas CO ₂	Function of combustion Efficiency
HCl emissions	1.8 kg/h or 1% of HCl concentration into the scrubber, whichever is greater
Particulate matter	180 mg/dscm corrected for O ₂
Scrubber effluent water	
2,3,7,8-TCDD	Not detectable
2,4,5-T	Not detectable
2,4-D	Not detectable
pH	5.5-9.5

a. Indicates parameter is a specified permit condition (Volume IV).

Versar, Inc. of Springfield, Virginia, obtained all onsite test samples and sent them to IT Analytical Services (ITAS) in Knoxville, Tennessee, for analysis. This work under contract to EG&G Idaho served as verification of test results. ITAS is a certified participant in the EPA Contract Laboratory Program (CLP). EG&G Idaho Chemical Sciences performed review of the ITAS QA/QC program prior to the laboratory analysis and later reviewed the submitted data.

B. FIELD ORGANIZATION

ENSCO performed the incinerator operation and soil excavation activities. Those activities were supervised by an ENSCO project manager located onsite. Reporting to him were the operations supervisor and a health and safety representative. The MWP-2000 operations were organized into two shift crews of about 10 personnel each for two shift operations. A skeleton crew was used for the remaining nonoperating idle condition shift.

Versar performed the onsite sampling with a crew of about 10 personnel. These activities were coordinated with ENSCO onsite supervision.

EG&G Idaho and AFESC project personnel provided the technical monitoring in the field. During field tests, this monitoring served to observe, direct (but not supervise) subcontractor personnel, and to ensure procedural compliance by the demonstration and sampling effort. AFESC project representatives were also onsite during the demonstration to provide liaison between the Air Force and the Navy, as necessary.

C. HEALTH AND SAFETY

1. Personnel

ENSCO prepared a Health and Safety Plan for the NCBC testing (Appendix H). This plan was derived from standard health and safety

procedures developed and used routinely by ENSCO personnel during operation of earlier units. It included unique aspects of the MWP-2000 and NCBC site. The plan was approved by certified industrial hygienists at both ENSCO and EG&G Idaho and met EPA Region IV approval through the permit process (See Volume IV).

Although no official permissible exposure limit for 2,3,7,8-TCDD exposure was in place at the time of testing, ENSCO used a company-imposed limit of 18 pg/m³ for its personnel at the NCBC operations. This value was based on a review of 2,3,7,8-TCDD risk assessments performed by regulatory agencies of the PCB transformer fires at Binghamton, New York, and One Market Plaza in San Francisco, California. Permissible exposure limits (8-hour time-weighted average) for 2,4-D and 2,4,5-T concentrations were 10 mg/m³ (Reference 25). The protective equipment requirements outlined below were specified to ensure adequate protection factors for possible exposure levels during operations. Field monitoring, discussed in Section IV.C.4, was performed to confirm that these requirements were adequate.

Class C respiratory protection and protective clothing requirements listed below were prescribed for all personnel within the contaminated zone:

- Tyvek^R disposable coveralls
- Powered air-purifying respirator (Protection Factor 150)
- Hard hat
- Chemical-resistant, steel toe and shank boots
- Boot covers
- Cotton inner gloves and rubber outer gloves.

Because the initial setup work was performed in a "clean" area, all workers complied with the usual industrial safety protective clothing requirements. The setup installation was made outside the restricted perimeter. Just before processing of contaminated soil, the barrier for the contaminated zone was moved to include the entire MWP-2000 installation. For further details, see Appendix H.

Because the process involved release of considerable heat, the required respiratory protection and protective clothing could have caused personnel heat stress, a serious concern. Therefore, heat stress of employees on the site was monitored by the Wet Bulb Glove Temperature Index (WBGT) technique, which uses a heat stress monitoring device such as the Wibget^R Heat Stress Monitor manufactured by Reuter Stokes. The WBGT is compared to the threshold limit value (TLV) outlined in Reference 23. Control measures to help reduce personnel heat stress were listed in the plan (Appendix H).

2. Soil

To control fugitive dust emissions, especially during soil handling, applications of dust suppressions (e.g., magnesium chloride) were planned, as necessary. During the verification test burn activities, sufficient rain occurred, therefore, special measures were not required.

A track-hoe excavator excavated the contaminated soil which was transferred to dump trucks and stockpiled near the weigh hopper. A bucket loader transferred the soil to the weigh hopper.

The incinerator ash drag dropped the treated soil into 20-cubic-yard rolloff boxes. A translift truck picked up the boxes and transferred the treated soil to a lined storage area onsite.

3. Equipment

Numerous safety interlocks for the MWP-2000 incinerator system are discussed in Appendix F. In addition, standard operating procedures were prepared for the operators to follow during normal and abnormal operations.

A number of system failures were addressed in the emergency and contingency plan (Appendix I). Fire and explosion were two potentially serious events. The risk due to fire was found acceptable based on the following:

- National Fire Protection Association and Factory Mutual approvals of shutoff devices for the incinerator's natural gas system
- Fire department inspection of the installation
- Fire department located only three blocks away
- A number of fire extinguishers (e.g., chemical powder, Halon, CO₂) were placed according to identified needs.

An explosion of the incinerator system with subsequent internal dioxin contamination to the workers at the HO site was considered to be the worst-case accident. Those workers who were not wearing respirators, if uninjured, could quickly don their assigned respirators and evacuate the immediate area, thus minimizing their risk. The injuries sustained to a worker explosion would be obviously much more significant than any potential injuries sustained as a result of dioxin contamination. Workers standing at the HO site boundary during such an accident could conceivably be exposed to dioxin during worst-case weather conditions. If an explosion were to occur, NCBC emergency response requirements would immediately be activated for notification and evacuation.

4. Spill Prevention Control

The following hazardous substances could be spilled during the MWP-2000 process, as identified in the spill prevention control and countermeasures plan (Appendix J):

- Small quantities of mercury (used in instrument calibration)
- ENT contents (could contain 2,3,7,8-TCDD, 2,4-D, 2,4,5-T if the incinerator was operated out of its operating limits)
- Fuel (diesel)
- Acids and caustics (used for boiler water treatment).

Where appropriate, additional countermeasures were included in the field setup. The plan specified procedures for spills if a spill did occur. See Appendix J for further details.

D. VERIFICATION SAMPLES

1. Sampling

To evaluate the effectiveness of ENSCO's incinerator for treating soil containing 2,3,7,8-TCDD and other chlorinated organics, Versar collected the following samples according to the sampling plan (Appendix K):

- Feedstock soil (untreated soil)
- Treated soil
 - kiln solids
 - ash drag solids
- Stack gas
- Effluent neutralization tank
- Quench/scrubber fines

- Boiler water blowdown
- Water discharge to POTW
- Blanks (tap water)

These sample points are identified in the incinerator process shown in Figure 22.

Because the ash-quench water originates from the ENT, unburned contaminants or products of incomplete combustion (PICs) that were scrubbed out of the off-gas could ultimately contaminate the ash-quench water and hence contaminate the treated soil in the ash drag. Therefore, two different treated soil samples were taken. One sample was taken before the treated soil came into contact with the quench water. These samples were called the kiln solids. The other sample was taken from the rolloff boxes where the ash drag deposits the treated soil.

To reduce the costs of analysis, the kiln solids samples were archived, pending results of the ash drag solids samples. If the ash-drag solids samples showed any signs of contamination, the kiln solids samples would have been analyzed to determine if the contamination came from the treated soil or the quench water. The analytical results for the treated scil (discussed in Section V.C.2) showed no contaminants of concern in the ash drag solids samples. Therefore, the kiln solids samples were never analyzed.

The sampling approach for feedstock and treated soil samples was to take grab samples at about 20-minute intervals with at least five grab samples making up a composite sample for each sample point. Each composite sample was then homogenized and a final aliquot sample was taken for analysis. The feedstock grab samples were obtained from the conveyor belt before the soil was transferred to the hopper. The kiln solids grab samples were taken at the exit of the rotary kiln before the water-quench and the ash-drag solids grab samples were taken from the treated soil in the rolloff box. Actual soil grab sample times for each test burn are shown in Section IV D.2.

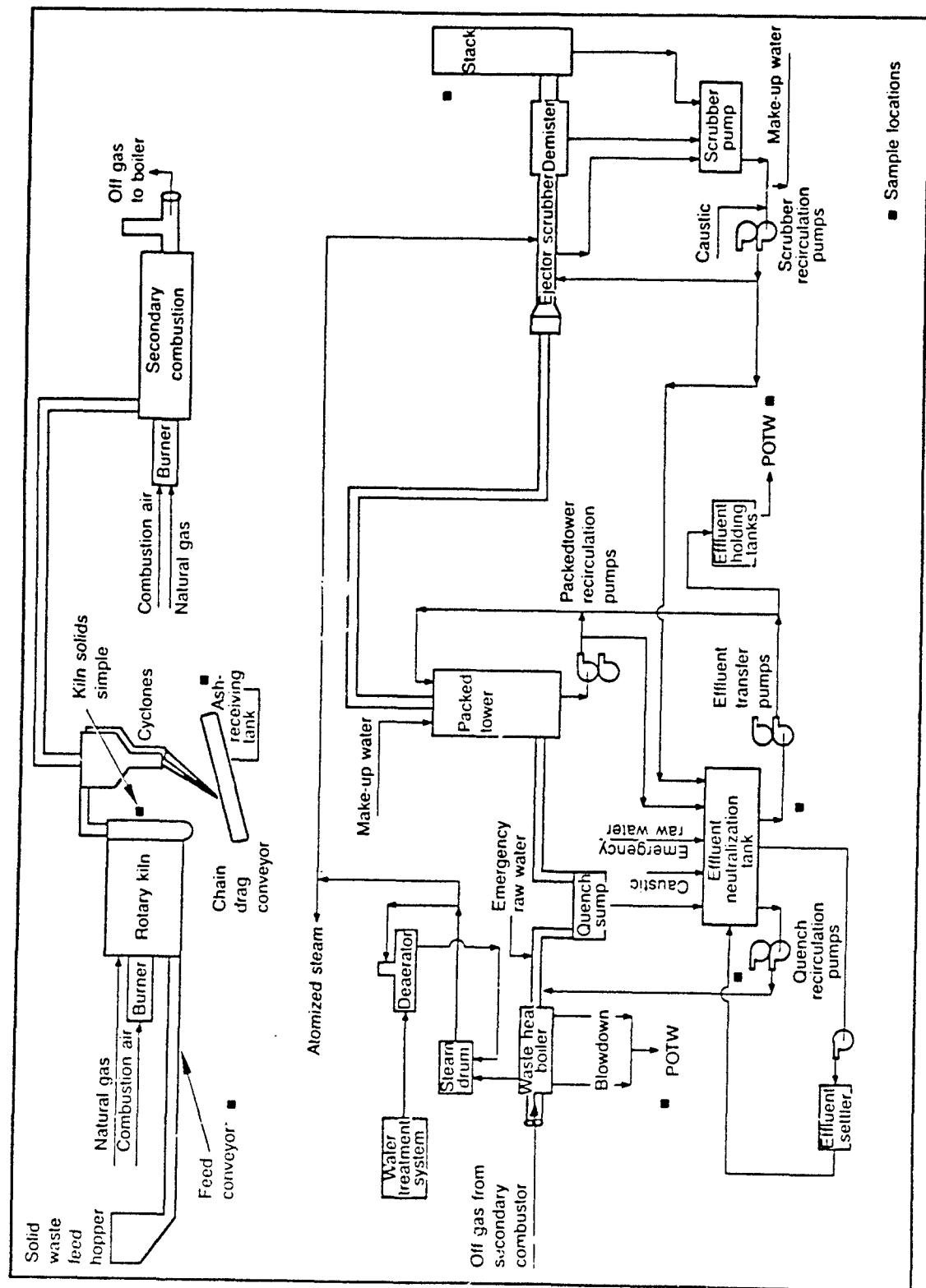


Figure 22. Sampling Locations for ENSCO MWP-2000 Incinerator System.

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Stack gas samples were obtained on the stack via two 4-inch flanges, located 90 degrees apart approximately 6 feet below the top of the stack. The specific methods used were an EPA Modified Method (MM5) gas sampling train and a volatile organics sampling train (VOST).

Water samples were obtained from the ENT via a valve located just downstream of the neutralization tank circulation pump. Samples of the quench/scrubber fines were obtained from the end of the discharge line to the fines settling tank. The boiler blowdown sample was obtained from a sample port located on the waste heat boiler. The sample of water to be discharged to the POTW was obtained from a sample tap located immediately after the water exits carbon adsorption but before the POTW holding tanks. The blank water sample was obtained from a supply water tap.

Sample collection and handling procedures were in accordance with EPA methods or acceptable protocols current at the time of the tests. Specific samples taken and methods/protocols followed are discussed in Section IV.D.

2. Shipping

All samples collected during the verification test burns were packaged and shipped to the analytical laboratory in accordance with U.S. Department of Transportation regulations. Packaging procedures are provided in Appendix K. To meet time constraints, all samples were shipped by Federal Express.

E. ANALYTICAL LABORATORY

A formal review of potential hazardous constituents, as listed in Appendix VIII of 40 CFR 261, of NCBC soil (References 17, 16, and 18) was conducted by EG&G Idaho and is referenced in Appendix A of the RD&D permit application (Reference 15). To meet the goals for the verification test burns (Section III.A), the laboratory analysis was intended to address the delisting requirements discussed in Section I.B.7, and to provide data that could verify that there were no hazardous waste streams released from the incinerator system.

Table 4 presents the recommended methods/protocols (from Appendix E, Exhibit 5) for analyzing constituents in untreated/treated soil, stack gas, scrubber water, and boiler blowdown water. For total dioxin/furan analysis, EPA Method 8280 (Reference 26) and the EPA CLP protocol were to be used to the extent possible. The CLP protocol was also applied for 2,3,7,8-TCDD specific analysis. It was anticipated that modifications to the CLP protocols might be necessary, primarily for the soil extraction procedure to reduce matrix interferences. It was also anticipated that concentrations of the spiking solutions and calibration solutions specified in the CLP protocols might need to be modified to more accurately reflect the analytical concentration range of interest, especially the need for very low detection levels. High-resolution gas chromatograph (HRGC)/high-resolution mass spectrometry (HRMS) was required for dioxin/furan analyses of treated soil samples because undetectable concentrations of dioxins/furans were expected; however, low-resolution mass spectrometry (LRMS) was specified for the analyses of feedstock soil samples because detectable concentrations of dioxins/furans were known from the characterization study (Reference 16). While standards obtained from commercial sources were permitted, it was required that all standards be verified for concentration using EPA and National Bureau of Standards reference standards.

In addition to the list in Table 4, the treated soil samples were required by EPA (Appendix E, Exhibit 6) to be analyzed for cyanide using EPA Method 9010 (Reference 26), sulfides using Method 9030 (Reference 26), and EP toxicity characteristics defined in 40 CFR 261.24, using the extraction procedure (EP) method specified in Appendix II of 40 CFR 261. Also, the EPA required that filters from the ambient air sampling to be analyzed for 2,4-D and 2,4,5-T using Method 8150 (Reference 26). Additional aqueous samples (scrubber, neutralization and boiler boildown) were for pH, total organic carbon (TOC), biological oxygen demand, chemical oxygen demand (COD), dissolved solids, and ammonia using standard methods.

Table 4. Required/recommended analytical methods and applicable detection limits

<u>Constituent</u>	<u>Analytical Method^a</u>	<u>Detection Limits ($\mu\text{g}/\text{kg}$)^b</u>
<u>Total Chlorinated Dibenzo-p-dioxins and Dibenzofurans</u>		
2,3,7,8-TCDD	CLPC	0.01 ^d
TCDD	8280, CLPe	--f
P ₅ CDD	8280, CLPe	--f
H _x CDD	8280, CLPe	--f
TCDF	8280, CLPe	--f
P ₅ CDF	8280, CLPe	--f
H _x CDF	8280, CLPe	--f
<u>Organics (Acid Extractables--Base/Neutral Extractables)</u>		
Benzidine	8250	44
bis-2-chloroethoxy methane	8010	--f
bis-2-chloroisopropyl ether	--g	--f
3,3-dichlorobenzidine	8250	16.5
2,4-Dichlorophenol	8040	0.39
2,5-Dichlorophenol	--g	--f
2,6-Dichlorophenol	8040	--f
	8250	2.7
3,4-Dichlorophenol	--g	--f
4,6-Dinitro-o-cresol	--	--f
2,4-Dinitrophenol	8040	13.0
2,4-Dinitrotoluene	8090	0.06
	8250	5.70
2,6-Dinitrotoluene	8090	0.06
	8250	1.6
2-Methylphenol	8040	--f
3-Methylphenol	8040	--f
4-Methylphenol	8040	--f
4-Nitrophenol	8040 ^h	2.8
	8040 ⁱ	0.70
	8250	2.4

Table 4. (continued)

<u>Constituent</u>	<u>Analytical Method^a</u>	<u>Detection Limits ($\mu\text{g/kg}$)^b</u>
N-Nitrosodimethylamine	8250	--f
Phenol	8040 ^h	0.14
	8040 ⁱ	2.2
	8250	1.5
1,2,3,5-Tetrachlorobenzene	--g	--
1,2,4,5-Tetrachlorobenzene	--g	--f
2,3,4,5-Tetrachlorophenol	--g	--f
2,3,4,6-Tetrachlorophenol	--g	--f
2,3,4-Trichlorophenol	--g	--f
2,4,5-Trichlorophenol	--g	--f
2,4,6-Trichlorophenol	8040 ^h	0.64
	8250	2.7
<u>Polynuclear Aromatic Hydrocarbons</u>		
Benzo(a)anthracene	8250	7.8
Benzo(a)pyrene	8100	--f
	8250	2.50
	8310	0.023
Benzo(b)fluoranthene	8250	4.8
	8310	0.018
Chrysene	8100	--f
	8250	2.5
	8310	0.15
Dibenzo(a,h)anthracene	--	--f
Fluoranthene	8100	--f
	8250	2.2
	8310	0.21
Iproto(1,2,3-cd)pyrene	8120	--f
	8250	3.7
	8310	0.043
<u>Organochlorine Pesticides, Polychlorinated Biphenyls (PCBs)</u>		
Toxaphene	8250	--f
PCB 1016	8080	--f
PCB 1021	8080	--f

Table 4. (continued)

<u>Constituent</u>	<u>Analytical Method^a</u>	<u>Detection Limits (µg/kg)^b</u>
PCB 1232	8080	..f
PCB 1242	8080	0.065
PCB 1248	8080	..f
PCB 1254	8080	..f
PCB 1260	8080	..f
<u>Herbicides</u>		
2,4-D	8150	1.0
2,4,5-T	8150	0.1
<u>Metals</u>		
Arsenic	..j	..j
Barium	..j	..j
Cadmium	..j	..j
Chromium	..j	..j
Lead	..j	..j
Mercury	..j	..j
Nickel	..j	..j
Selenium	..j	..j
Silver	..j	..j
<u>Miscellaneous</u>		
Coal tars	..g	..f
Creosote	..g	..f
Hydroxydimethylarsine oxide	..g	..f

a. Where analytical methods are specified, they are from EPA SW-846 (Reference 26).

Method 8010, Halogenated Volatile Organics

Method 8040, Phenols

Method 8080, Organochlorine Pesticides and PCBs

Method 8090, Nitroaromatics and Cyclic Ketones

Method 8100, Polynuclear Aromatic Hydrocarbons (GC Method)

Method 8250, GC/MS Method for Semivolatile Organics: Packed Column Technique

Table 4. (continued)

Method 8280, Method of Analysis for Chlorinated Dibenzo-p-dioxins and Dibenzofurans

Method 8310, Polynuclear Aromatic Hydrocarbons (High Performance Liquid Chromatographic Methods)

Except for dioxins/furans (see footnote c), the methods contract recommended procedures for the other listed constituents. The analytical laboratory should apply its expertise and ability for a method/protocol it is familiar with which will result in the lowest detection level possible and which will be acceptable to the regulatory agencies.

b. Detection levels are $\mu\text{g}/\text{kg}$ in water as stated in the cited EPA method. Soil values may be higher but must be lowest possible, utilizing the most sensitive equipment available.

c. There is no published method. The EPA CLP applied to the extent possible.

d. Required detection limit specified in the EG&G Idaho contract with ITAS.

e. Analyses for total dioxin/furan isomers of tetra-, penta-, and hexa- to follow Method 8280 (Reference 26) plus CLP protocol to the extent possible.

f. No detection limit specified. Detection level must be the lowest possible, using the most sensitive equipment available.

g. No protocol specified. Protocol used must produce the lowest detection level possible and be recognized as the CLP or industry standard. Protocols used must be approved by EG&G Idaho, Chemical Sciences Group.

h. Flame ionization GC procedure in Method 8040.

i. Electron capture GC of pentafluorobenzyl-bromide (PFB) procedure in Method 8040.

j. For metal analysis, the protocol utilized must produce the lowest detection limits possible and results should indicate amount present. In addition, EP Toxicity ($6.3 \times$ drinking water standards) should be reported.

ITAS' analytical procedures were in accordance with EPA methods or CLP protocols. Further, a quality assurance plan was associated with these analyses and was evaluated by EG&G Idaho. The analyses according to each sample, methods/protocols, validation, and results discussion are presented in Section V.

F. WASTE DISPOSAL

Disposable contaminated nonsoil materials generated during the test burns (e.g., used personnel protective clothing/equipment and sampling equipment) were placed in sealed plastic bags and set aside in a protected area. Items that could not be decontaminated were processed through the MWP-2000 incinerator system later.

SECTION IV

FIELD OPERATIONS

A. DESCRIPTION OF SITE SETUP

The MWP-2000 verification tests burns at NCBC were done at a location within the former HO storage site selected by EG&G Idaho, AFESC, and ENSCO project personnel and NCBC base officials. Figure 23, a map of the site layout, indicates the various principal test-related facilities. The entire site was remote from other active facilities on the base, and the road and track to the site were inactive during the entire demonstration period. Figure 24 is a photograph of the MWP-2000 incinerator system and surrounding area facilities.

Utility connections to base systems for natural gas, water supply, sewer, and electrical power were made to operate the MWP-2000 incinerator system.

The specific area selected for placement of the incinerator operations was just inside the southeast perimeter of the restricted (HO contaminated) area (Lot 63), which lies adjacent to Greenwood Avenue and Track D (Figure 23). Based on soil sampling program results (Reference 16), this location was found to have dioxin contamination less than 1 ppb so it could be declared a clean area (Area 2) for ease of installing the MWP-2000 incinerator system and performing clean soil checkout operation. Figure 23 shows the location of equipment in the incinerator area. The personnel decontamination trailer was located in Area 2 on the railroad track inside the chain link fence. A gate near the decontamination trailer provided access through the fence to Area 2 from an unrestricted clean area, designated as Area 3 (Figure 25). Once contaminated soil was being processed, the designation of Area 2 changed from a "Clean Area" to a "Reduced Contamination Area." Access-exit on the Area 2 side of the decontamination trailer included a covering where personnel protective clothing and respirators were stored when not in use (Figure 26). The support facilities, including office trailers and a

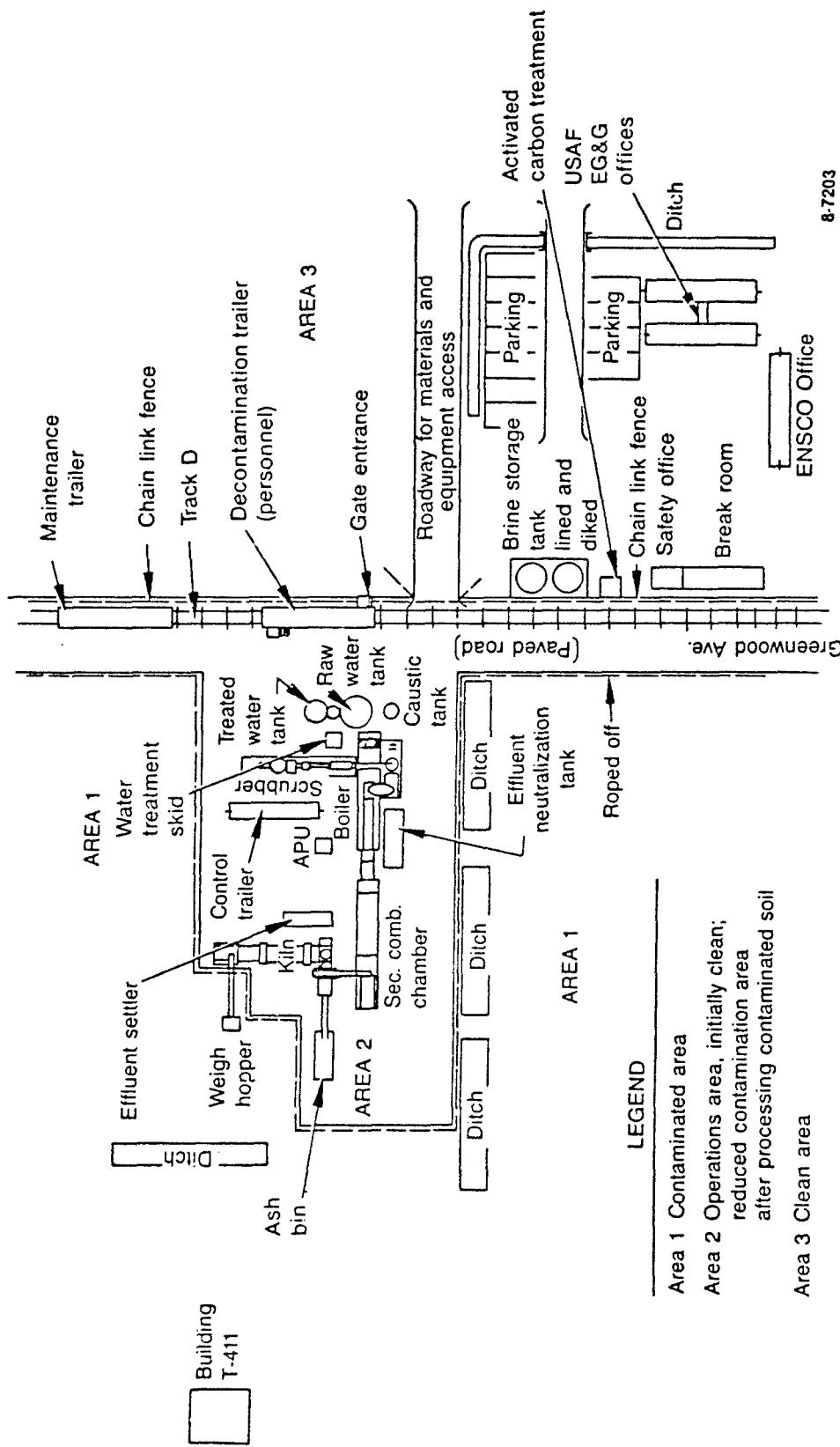


Figure 23. Site layout for MWP-2000 incinerator setup at NCBC.

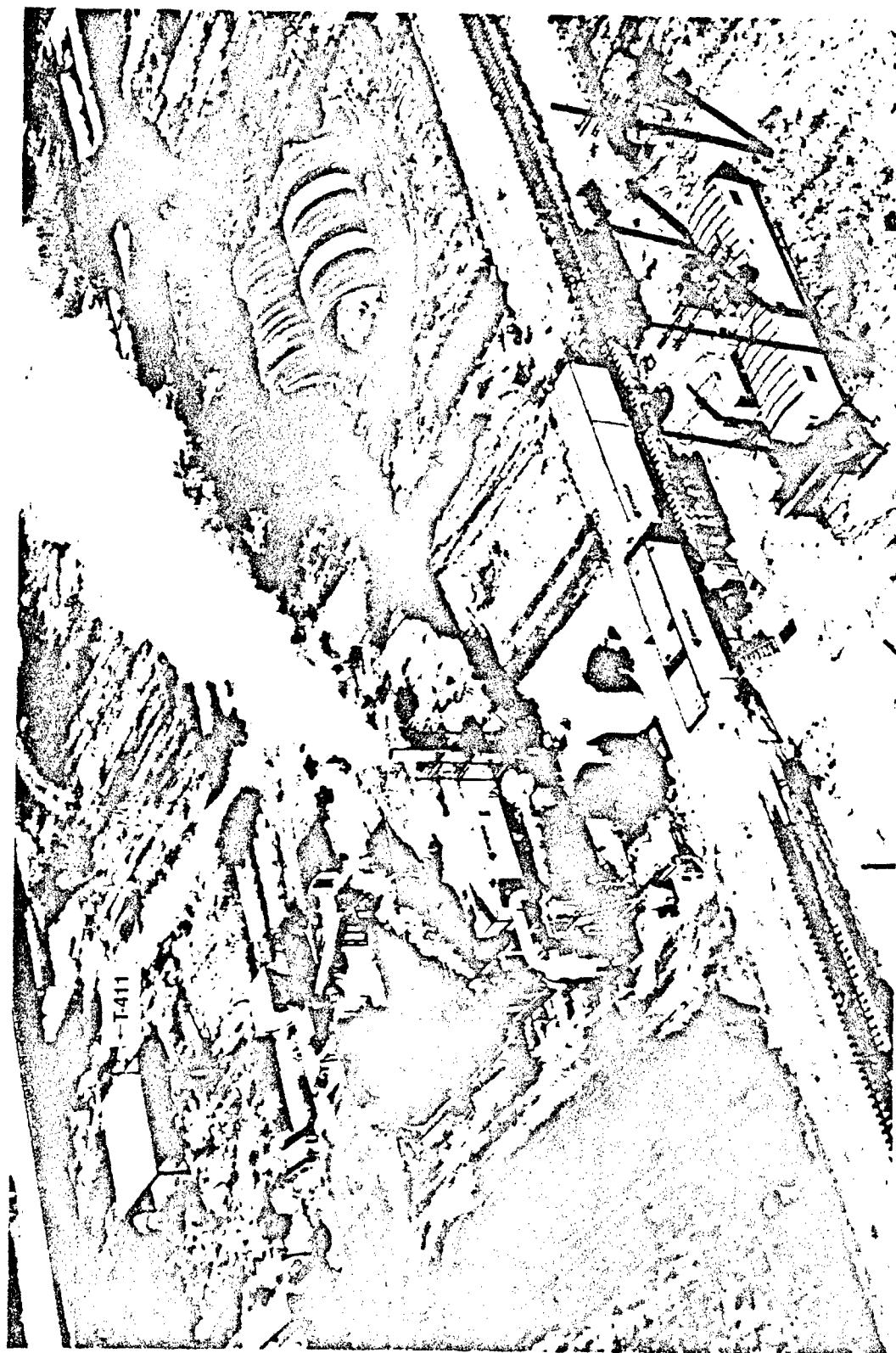


Figure 24. Aerial photograph of HO site with MWP-2000 incinerator and supporting facilities.

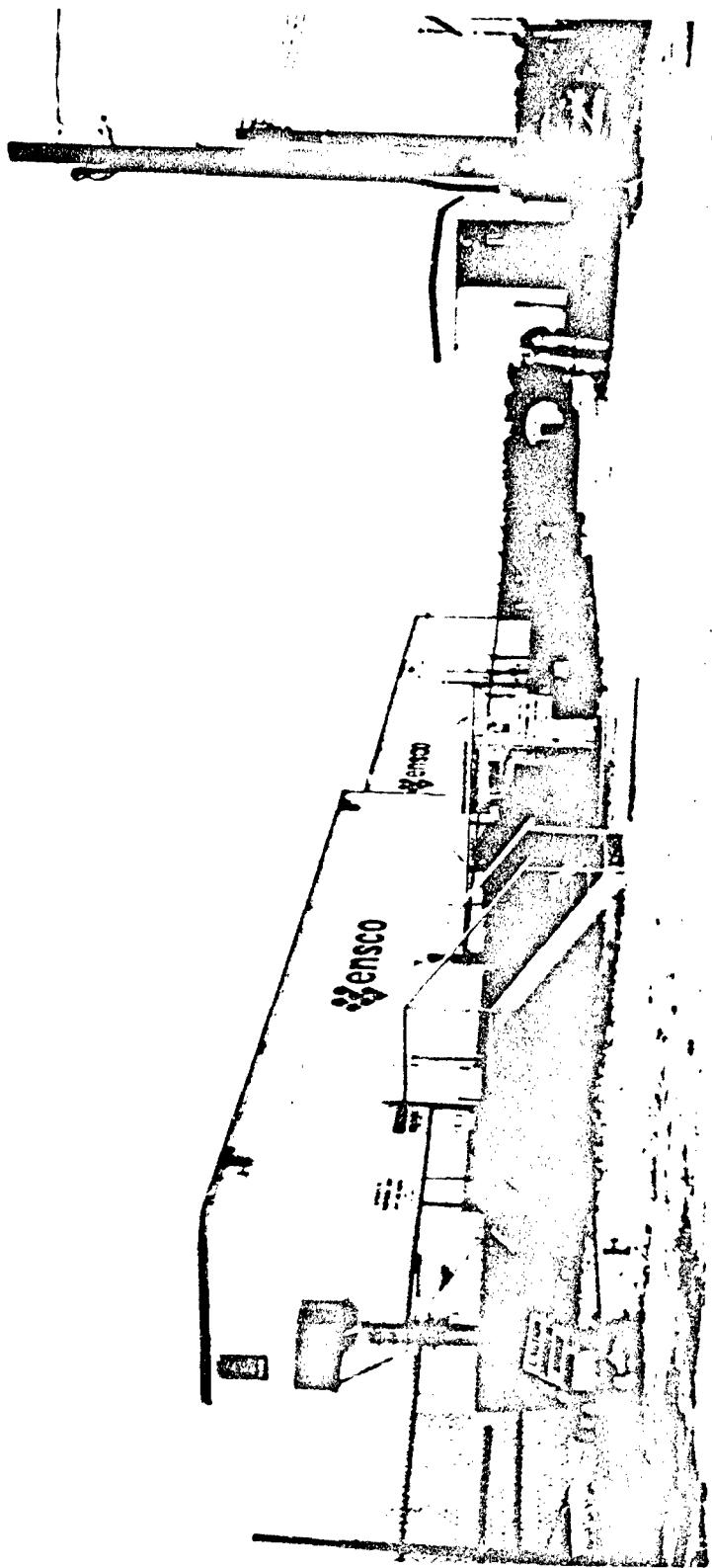


Figure 25. Entrance to site through chain link fence area via personnel decontamination trailer.

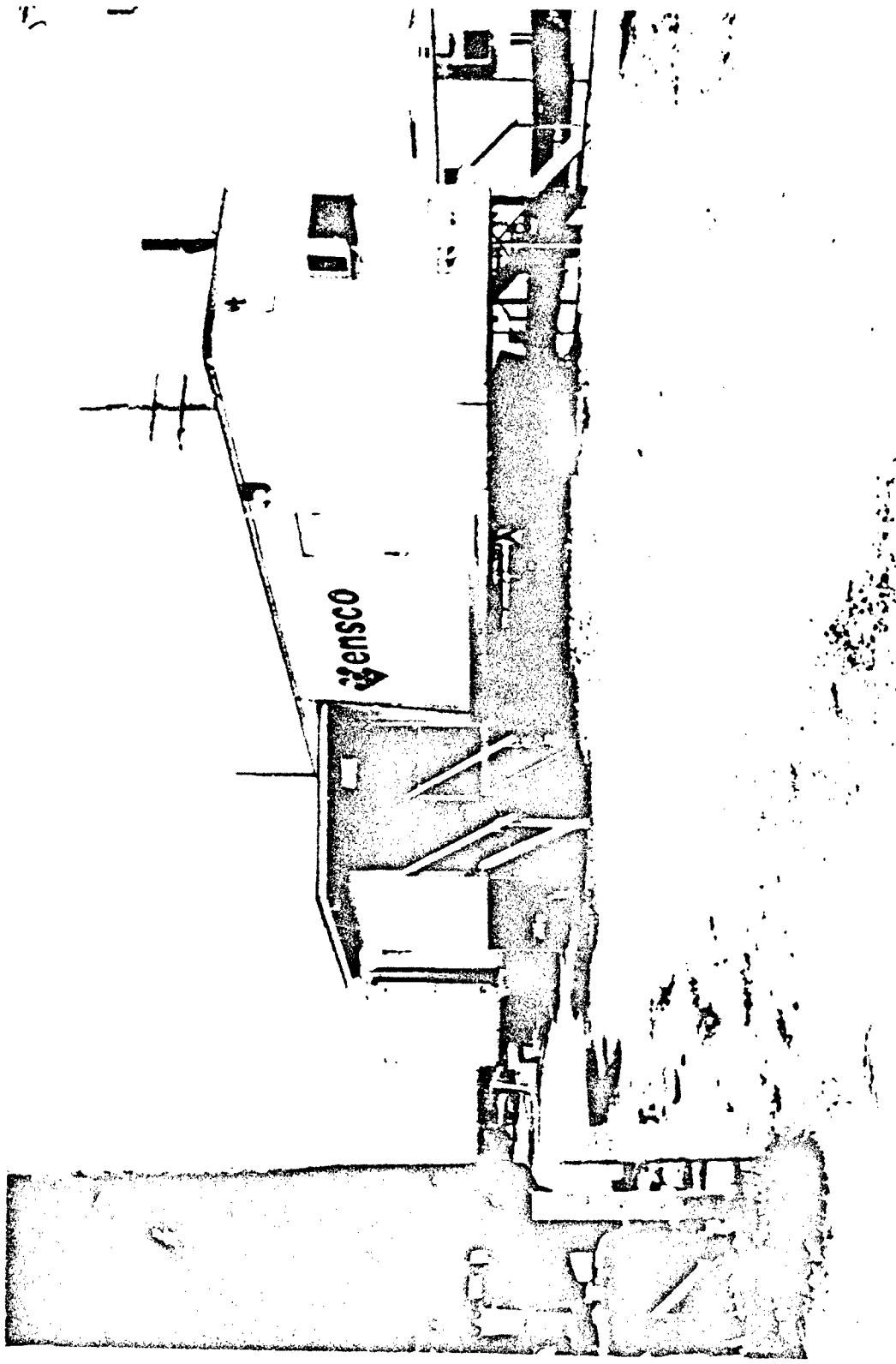


Figure 26. Site side entrance to personnel decontamination trailer.

personnel break room, were placed in the unrestricted area (Area 3 in Figure 23) across the paved road and railroad track to the southeast (Lot 43). Although located on the railroad track inside the chain link fence (behind decontamination trailer in Figure 25), the maintenance trailer was in a declared clean zone.

A number of other supporting process features were NCBC site-specific. During the verification test burns, excavated material was stored at NCBC Facility T-411, which consisted of a concrete pad with a roof covering (Figure 27). Building T-411 was originally used as the dedrumming area during the HO storage era. The control trailer was located in the middle of the U-shape formed by the three flatbed trailers (i.e., kiln, SSC, air pollution control train). In Figure 28, the kiln is on the right of the trailer and the stack is on the left. Raw water pumped from the NCBC wells was stored in two tanks (Figure 29). The caustic tank is shown on the left in same photograph (note the spill dike) while the chemical treatment tank skid is shown in front of the stack. The two storage tanks used to store waste effluent to be released to the NCBC sewer line for POTW treatment are shown in Figure 30. These tanks were set up outside the chain link fence. Spill protection was provided by the diked covered ground surface around the tanks.

Because the MWP-2000 incinerator requires low-silica water to facilitate waste heat boiler operation, samples were collected from all five NCBC potable water supply wells and at the site distribution system. The results (22-48 mg/L, Appendix L) showed the silica levels in the potable water to be unacceptably high for use in the waste heat boiler. This would cause boiler scaling. High blowdown rates to prevent scaling would result in loss of steam volume and subsequent unacceptable reduction of the injector scrubber draft. This problem was temporarily resolved by



Figure 27. View of bulk material storage area of T-411 facility.

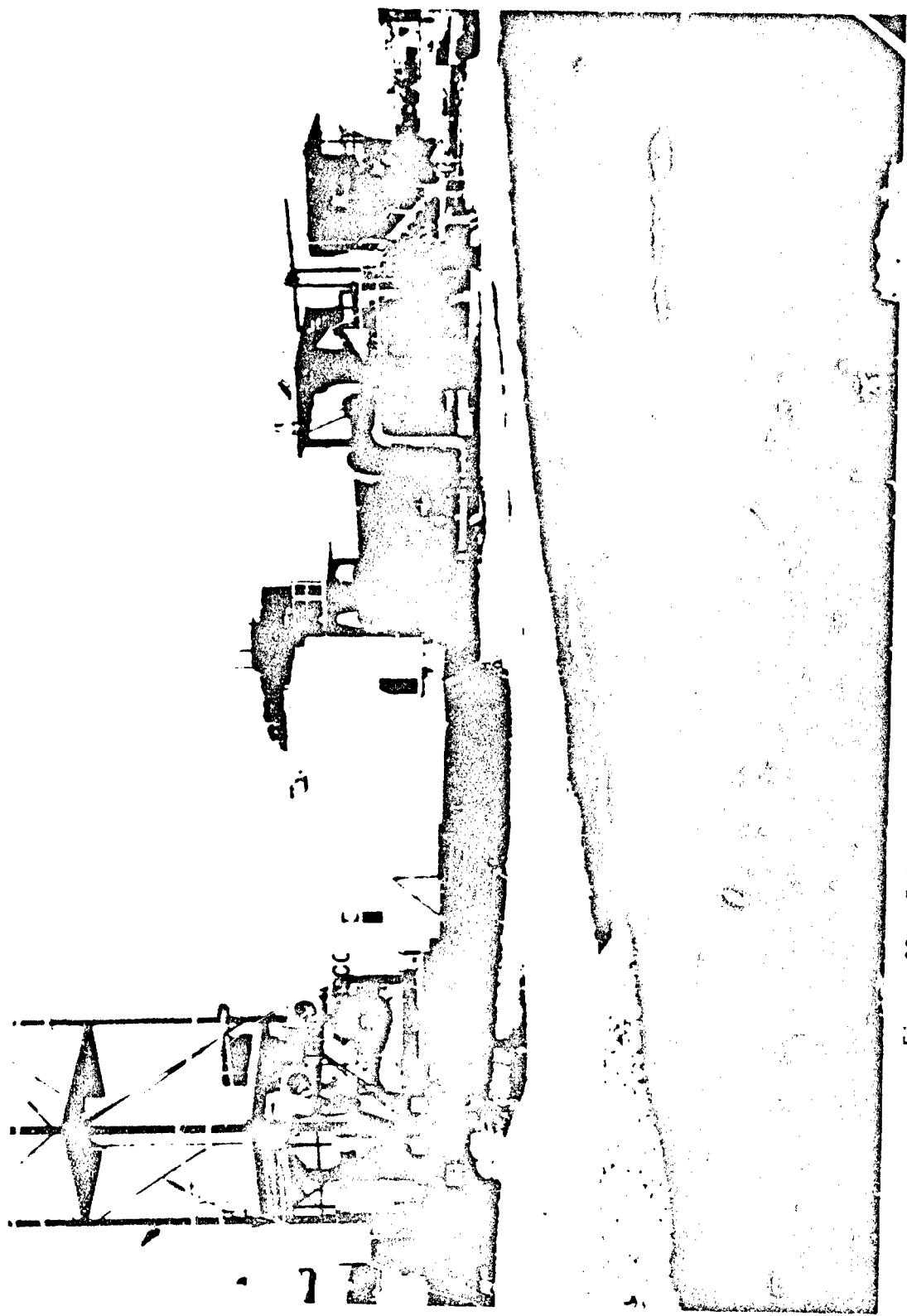


Figure 28. External view of NWP-2000 incinerator system control trailer.

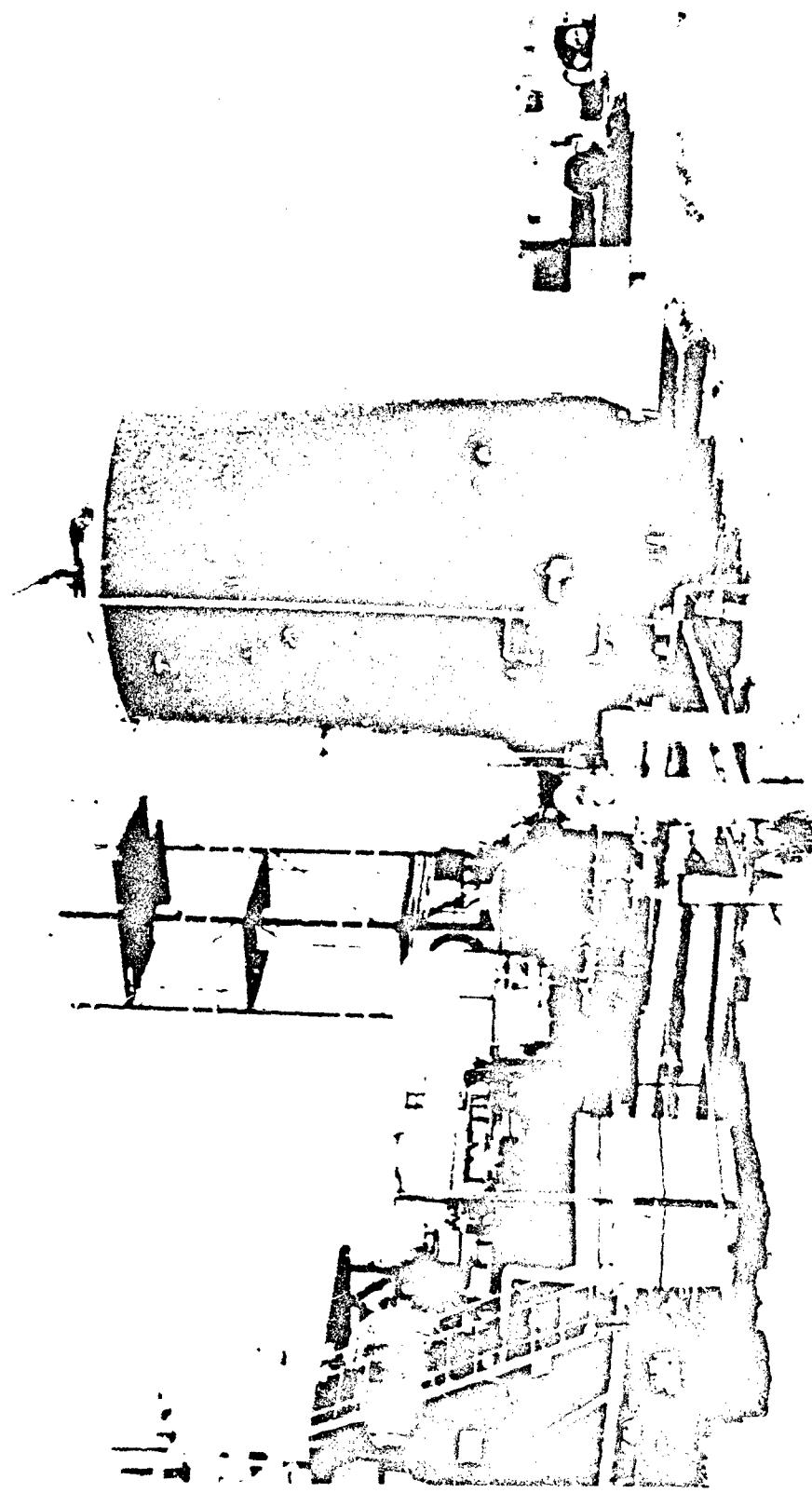


Figure 29. View of raw water supply tanks, caustic tank, and chemical treatment tank skid.

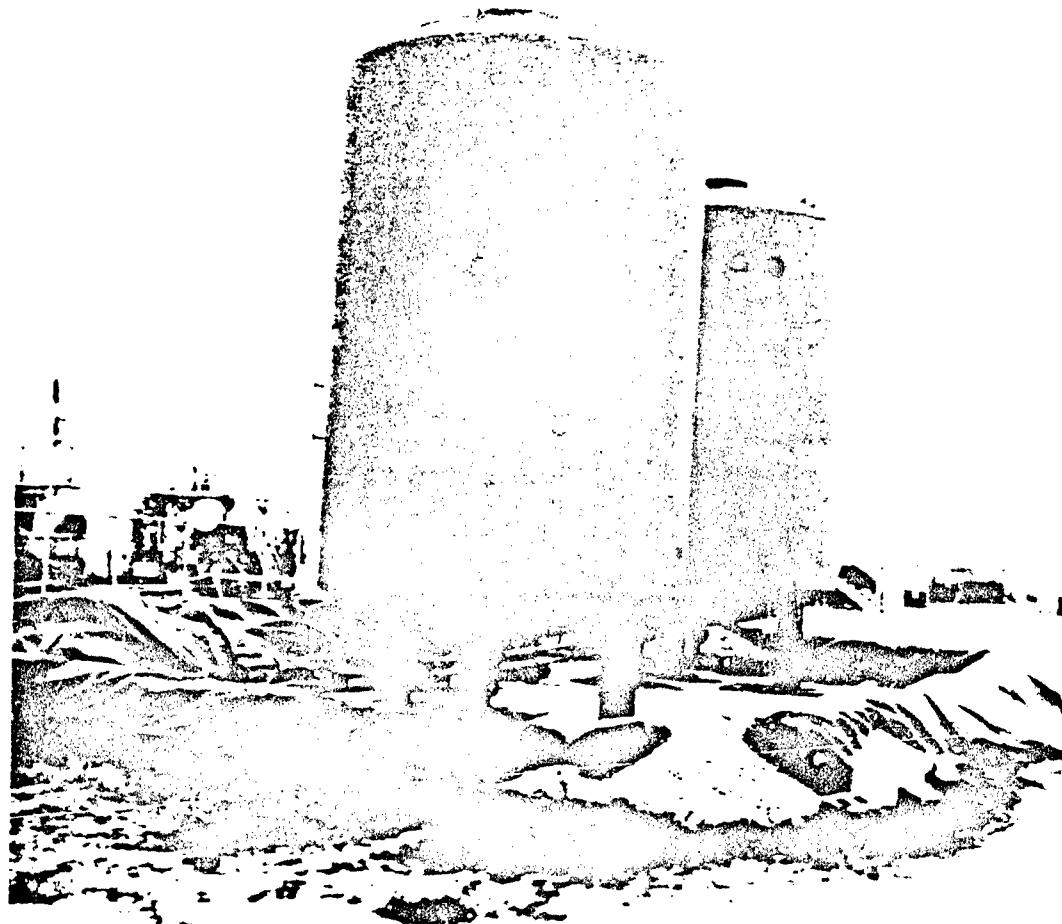


Figure 30. View of waste water storage tanks for POTW.

leasing of a tractor-trailer-mounted deionizer unit, which was used to treat supplied water being fed to the waste heat boiler. After completion of the verification test burns, the Air Force purchased a desilicasizer unit for economical routine operations.

Inspection of the planned slurry discharge (containing settled solids) from the ENT to the ash drag revealed an unacceptable condition because of possible presence of PICs. A modification was made by pumping solids accumulated in the ENT to a sealed translift rolloff box. Supernatant from the rolloff box was recycled to the effluent neutralization tank. The solids were held pending results of the ENT sample analysis. If that analysis showed evidence of contamination, the solids in the rolloff box would have been sampled. Because the analysis results, discussed in Section V.C.4, showed the ENT sample to be "clean," the rolloff box contents were also declared "clean."

B. SOIL FEEDSTOCK

1. Selected Plots

Based upon the characterization studies (Reference 16), the plots with the highest level of 2,3,7,8-TCDD surface contamination were selected for processing. Those plots were selected from the original HO storage area (Area A) located between Greenwood and Goodier Avenues (see Figure 2). The 10 plots excavated were in three groupings and are listed below by an alphanumeric coding with the surface contamination level from the characterization study shown.

<u>Grouping</u>	<u>Plot Code*</u>	<u>2,3,7,8-TCDD Contamination Level (ppb)</u>	<u>Approximate Location</u>
1	AB-39	242	About 70 feet northwest of T-411 facility in NCBC Lot 63
2	AC-45 AD-45	390 230	About 100 feet north of T-411 facility in NCBC Lot 62

2,3,7,8-TCDD
Contamination Level

<u>Grouping</u>	<u>Plot Code^a</u>	<u>(ppb)</u>	<u>Approximate Location</u>
3	AW-70	200	
	AW-71	260	
	AW-72	280	
	AW-73	207	
	AW-74	163	
	AW-75	45 ^b	
	AW-76	207	

- a. The plot code is read as follows using AB-39 as an example: "A" represents Area A. "B" represents the row in a matrix format running parallel to Track E by Goodier Avenue "39" represents the column in a matrix format which runs perpendicular to Goodier and Greenwood Avenues.
- b. Although not high concentration, this plot was excavated for convenience because it was located between two plots of high concentration.

These plots were selected in an effort to determine the performance parameters of the MWP-2000 incinerator system while processing the most contaminated soil available, i.e., "worst-case" conditions. However, visual inspection of plot AY-58, the most contaminated plot (650 ppb 2,3,7,8-TCDD) based upon the characterization study, indicated that the soil on that plot contained substantial quantities of oyster shell, asphalt, and road oil. Therefore, onsite project personnel decided that the soil in that plot was unique and not representative of the site as a whole and, thus, did not elect to use it for the verification test burns.

In addition to excavating the aforementioned contaminated plots, approximately 240 tons of noncontaminated soil (defined as having less than 1.0 ppb of 2,3,7,8-TCDD) was excavated from the northeast corner of Area A. That soil was processed before each test to establish steady-state conditions within the kiln and the rest of the incinerator.

Soil excavations were made to a depth of about 1 foot using a Case track hoe (Figure 31). The soil was then loaded into a dump truck for hauling to the soil preparation area. The clean soil was excavated first because of planned use and because once inside the contamination zone the equipment was declared contaminated. This equipment remained inside the contamination zone for the remainder of the verification test burns. With completion of the tests, the track hoe was decontaminated, swipe sampled, and returned to the lessor.

2. Staging Area Preparation

The dump truck soil loads were planned to be brought to the bulk material staging area adjacent to the weigh hopper. Because of excessive rains during the contaminated soil excavation phase, this soil was dumped into one large pile at building T-411 (Figure 27), which was located within the storage site. To provide feedstock under the prevailing conditions, soil was hauled by front end loader from the T-411 storage area to the operations area and unloaded into the weigh hopper (Figure 7).

Preliminary processing of clean soil had indicated that excessive moisture in the soil was causing undesirably low feed rate. Therefore, in an attempt to reduce the soil moisture content, four 15,000 Btu/hr Salamander heaters were set up in the corners of the concrete pad. Polyethylene sheeting was hung from the sides of the building to help retain the heat and to prevent additional rain from blowing onto the soil. This effort was largely unsuccessful because only the top 2 inches of the soil pile dried; deeper soil observed no drying effects. Front-end loaders were used to mix the soil so that the moist soil underneath could be brought to the top for drying, but due to the large quantity of soil and the limited floor area of Building T-411, that effort was also largely unsuccessful.



Figure 31. View of soil being excavated for test burns.

To ensure that sufficient levels of 2,3,7,8-TCDD were present in this pile of feedstock, composite samples were collected for analysis. Results indicated an average concentration of about 50 ppb. More detailed results are given for the feedstock samples taken at the weigh hopper for the individual test burns (see Section V.C.1.a).

This concentration was significantly below the concentration reported in the characterization study (Reference 16) for the plots excavated. This is probably caused by the blending of the highly contaminated surface and near-surface soil (0-2.5 in.) with lesser contaminated soil at depth. Degradation of the 2,3,7,8-TCDD is not a satisfactory explanation because the duration subsequent to the characterization sampling, which was done 1984-1985, was only about 2 years. The half-life for soil-bound 2,3,7,8-TCDD exposed to natural conditions, primarily sunlight, is about 10-12 years (Reference 9).

Because of the nature of chemical spills and because of dioxin's strong affinity for soil, subsurface contamination of HO is preceded by surface contamination. Therefore, the soil excavated and processed for the verification test burns represents the most highly contaminated soil onsite.

C. INCINERATOR ACTIVITIES

1. Overall Field Activities

The onsite activities supporting the verification test burns began August 25, 1986, and were completed on December 15, 1986, with the last two of six test burns. EG&G Idaho and AFESC representatives arrived onsite, set up project operations, and coordinated utility installation. ENSCO project supervision arrived onsite a week later and began preparation that included hiring of local personnel, meeting with vendors, and additional utility installation.

The incinerator and supporting equipment arrived at the NCBC on September 17 on 13 tractor-trailers. Four of those trailers contained the kiln, the SSC, the boiler, and the jet-scrubber. The control room arrived on a separate trailer as did the maintenance/spare parts trailer and the boiler ancillary devices. The remaining six trailers contained miscellaneous piping, duct work, and scaffolding. Three additional trailers of miscellaneous heavy equipment and ancillary equipment arrived later in the month. The personnel decontamination trailer arrived in November, just before the verification test burns. System setup began on September 29 and continued through November. The refractory was installed into the system on site because the kiln and SCC with the refractory installed would have exceeded the allowable highway weight restrictions.

System checkout began in a parallel effort with setup completion on November when the kiln and SCC were fired with natural gas to cure the newly installed refractory. Checkout and instrument calibration continued until November 24 when the first clean soil test was attempted.

Numerous problems with the solids feed system plagued the clean soil test. In particular, the hydraulic motor on the shredder below the weigh hopper failed and ruptured hydraulic seals. Availability of replacement seals threatened the test schedule. The failure was ultimately diagnosed as a seized hydraulic motor, and the motor was replaced. Additionally, the ash drag chain conveyor failed because of design problems associated with the conveyor bearings. Because the failure occurred beneath the quench water level, the unit had to be cooled down to allow draining of the quench water and repair of the conveyor. These problems are discussed further in Section VI.E.

Because of the equipment problems mentioned previously, numerous other mechanical failures, and the impending Thanksgiving holiday, project management decided to delay the contaminated soil testing until late the following week. The added time allowed repair and additional preparation for the contaminated soil test.

Clean soil testing commenced on December 2 following the holiday. Clean soil testing was also conducted on December 3 and 5, after which the MWP-2000 incinerator was considered ready for test burns with contaminated soil.

The verification test burns with HO-contaminated soil were conducted on December 6, 7, 8, and 15, 1986, and consisted of six tests. The following list provides the average feed rate, duration, and date performed for each test burn.

<u>Test Burn</u>	<u>Soil Feed Rate (tons/hr)</u>	<u>Duration (minutes)</u>	<u>Date Performed</u>
1	2.8	76	12-6
2	3.6	75	12-7
3	3.7	70	12-7
4	3.7	67	12-8
5	5.2	70	12-15
6	6.3	70	12-15

Following the final test burn, the MWP-2000 incinerator system was shut down to await EPA authorization to commence routine operations. Because analysis of the collected samples, evaluation of the data, presentation of the data to EPA Region IV, and subsequent AFESC/EG&G Idaho interaction with the regulatory agency could involve a considerable period of time, the ENSCO crew was reduced to a size sufficient for security and maintenance.

2. Test Procedures

a. Clean Soil Test

In preparation for the clean soil testing, the incinerator was brought up to temperature with natural gas. The system temperatures were manually allowed to rise to their normal operating conditions of 1200 to 1600°F for the kiln and 2150°F for the SSC. Clean soil was placed in the hopper and initially fed at a feed rate of approximately 1 ton/hr. This rate was continued for about an hour while the kiln operating parameters stabilized.

On December 2, clean soil was processed for eight continuous hours at a feed rate of approximately 5 ton/hr. Clean soil was also processed for several hours on December 3 and 5 each. Although the original test plan called for a 72-hour continuous clean soil test that would provide a total system checkout, management decided to accept the existing processing time as evidence of system readiness. This decision was made to reduce the costs associated with anticipated additional delays.

During the tests, all normal operating parameters (Table 3) were monitored. Listed data were recorded by computer printouts every 15 minutes.

b. Test Burns

The system was started up for Test Burn 1 as discussed for the clean soil test. Clean soil was fed to the incinerator from 0645 to 0900 to establish steady state incinerator operating conditions. Because the residence time of soil in the kiln was expected to be approximately 30 minutes, contaminated soil was not fed to the incinerator until 0930. This time delay ensured that any ash or kiln soil samples collected would be representative of the contaminated soil being processed. The stack gas sampling began at approximately 1100 and was completed at 1330. Kiln solids and ash drag sampling began at approximately 1000 and was completed at approximately 1400. Actual average feed rate and duration are shown in Section IV.C.1. All normal operating parameters (Table 3) were monitored and recorded on the computer every 15 minutes. Samples were collected at the required frequency (see Section IV.D.2). Because testing occurred the next day, the system was left in standby mode.

On December 7, the Test Burns 2 and 3 were conducted. Clean soil feed to the incinerator began at 0400 with a mass feed rate of approximately 5 ton/hr. Clean soil feed was discontinued at approximately 0730. Contaminated soil feed began at 0800 and continued until 1605 when the Test Burn 3 was completed. Test Burns 2 and 3 were conducted at feed rates of 3.64 and 3.71 ton/hour, respectively. Analyses of the operational data for those tests revealed that the ejector scrubber was working at its maximum capacity and that no higher suction (draft) could be expected for future tests. Because the future tests were planned for 4 and 5 ton/hr, and because the soil moisture content was quite high, operational personnel realized that the jet configuration could not produce sufficient draft to process soil at the higher feed rates. Therefore, a decision was made to modify the ejector scrubber nozzles so that additional steam that was being wasted could be utilized in the scrubber to produce additional draft.

On the evening of December 7, the jet nozzle was removed and machined to a larger diameter. The machined nozzle was installed by 0600 on December 8. The results were highly successful; the wasted steam was able to be utilized by the jet to produce sufficient draft for the higher feed rates tests.

The test planned for Test Burn 4 was to be conducted at a minimum feed rate of 4.5 ton/hour; however, the feed rate varied from 1.9 to 5.2 ton/hr with an average feed rate of approximately 4.0 ton/hr. Because the variability of the feed rate and the closeness of the average feed rate to the two previous tests, it was decided to discard the samples collected for that test so that no analytical costs would be incurred. Because the data for Test Burn 4 were never analyzed, further discussion is excluded from this report.

During the afternoon of December 8, another test was attempted; however, the leak check for the VOST sampling train caused delays. Later in the day, severe weather forced the sampling crew off the stack; no additional tests were attempted on that date.

On the morning of December 9, visual inspection of the boiler face plate revealed significant particulate buildup resulting from particulate carryover from the kiln. Additionally, condensed silica on the inside of the boiler tubes resulted in high boiler inefficiencies.^a Early in the test series, water spray nozzles were placed into the cross over T section between the SCC and the boiler in an attempt to condense molten and vaporous silica before entering the boiler tubes. During Test Burn 3, the spray nozzles were errantly turned off in a failed attempt to reduce the gas flow to the jet and also to increase the inlet temperature to the boiler. Unfortunately, this action had the detrimental effect of allowing the vaporous and molten silica in the SCC off-gas to condense and foul the boiler tubes.

On December 10, severe weather forced postponement of tests. Bad weather continued to plague the area until late on December 14. The system was maintained in standby mode.

Better weather on December 15 allowed completion of Test Burns 5 and 6. High average soil feed rates were achieved at 5.2 and 6.3 ton/hr., respectively. General procedures discussed for Test Burn 1 also applied for these two test burns.

c. Inprocess Monitoring

In addition to the on-line monitoring already discussed, boiler water samples were taken to ensure proper water quality. Analyses were performed by ENSCO personnel in their boiler water laboratory trailer, located in the adjacent area.

a. This silica condensation problem is unrelated to the previously mentioned dissolved silica problem. The dissolved silica was a concern with respect to fouling of the water side of the boiler tubes. The condensed silica issue is a result of vaporous silica from the sand in the processed soil condensing on the inside of the relatively cool boiler tubes.

3. Incinerator Operating Conditions

a. RD&D Permit Requirements

The RD&D permit specified three performance standards for the MWP-2000 (from Volume IV):

1. The incinerator must achieve a destructive removal and efficiency (DRE) of 99.9999 percent for 2,3,7,8,-TCDD and dibenzofuran.
2. Control HCl emissions such that the rate of emissions is no greater than the larger of 1.8 kg/hr or 1 percent of the HCl in the stack gas prior to entering any pollution control equipment.
3. The incinerator must not emit particulate matter in excess of 180 milligrams per dry standard cubic meter when corrected for the amount of oxygen in the stack gas in accordance with the formula specified in 40 CFR 264.343(c).

The associated permit specified operating conditions to support these performance standards as listed in Table 5. The permit also specified that, during startup and shutdown of the MWP-20000, hazardous waste must not be introduced into the incinerator unless the incinerator is operating within the conditions specified in Table 5. Region IV also specified four minimum conditions (e.g., SSC outlet temperature, oxygen concentration in the stack gas, combustion efficiency, residence time), as shown in Table 5, that require the operator to immediately cut off the hazardous waste feed to the incinerator when any of the conditions occur.

Table 5. RD&D permit specified operating conditions for MWP-2000 incinerator system operation at NCBC

<u>Parameter</u>	<u>Operating Range^a</u>	<u>Feed Cutoff Limits^a</u>
Kiln outlet temperature ^b	1200-1800°F	--
Kiln pressure	Negative ^c	--
SSC outlet temperature ^b	2150°F	<2100°F
SSC pressure	Negative ^c	--
Oxygen concentration in stack gases	--	<3% by volume
Combustion efficiency ^d	--	<99%
Residence time ^e	1-2 seconds	<1 second
Recirculation flow rate to packed tower	-- ^f	--
Recirculation flow rate to scrubber	-- ^f	--

a. Permit requirements from Volume IV.

b. As measured by outlet gas thermocouple.

c. To control fugitive emissions from combustion units.

d. As measured by $100 \times CO_2/(CO_2 + CO)$ where CO and CO_2 , respectively, are the carbon monoxide and carbon dioxide concentrations in the stack gases.

e. As calculated from mass flows and gas temperature.

f. Shall be maintained to meet scrubber efficiency requirements.

b. Verification of Test Burns

Six verification test burns were conducted, treating approximately 100 tons of contaminated soil. The average operating parameters for each test, based on the 15-minute interval recording by the computer, are summarized in Table 6. Maximum and minimum values of pressure and temperature for the kiln and SSC also are shown.

The bulk soil feed rate profile over the elapsed time for each test is shown in Figure 32. The soil feed rate to the incinerator was determined by manually recording the initial and final weights of the weigh hopper and the time of day as soil was placed into the hopper. The mass feed rate was then calculated by:

$$\frac{(\text{Final weight}) - (\text{initial weight})}{dT}$$

where dT is the time between the previous soil loading and the current soil loading. Because the feed rate varied with any particular test burn and the weigh hopper weights were recorded at irregular intervals, the data shown in Figure 32 were smoothed using a three-point moving average. The bulk average feed rate listed in Table 6 was computed by dividing the total mass of soil fed to the weigh hopper during a test burn by the total elapsed time of the test burn.

Fifteen-minute interval profiles for the kiln and SSC temperatures for each test are shown in Figure 33 and 34, respectively. Individual curves for soil feed rate, kiln temperature, SSC temperature, kiln draft, SSC draft, stack oxygen concentration, combustion efficiency, and stack carbon monoxide concentration during the test burn days are shown in Appendix M (Exhibits 1-3).

Table 6. Summary of incinerator operating conditions during verification test burns

Parameter	Test Burn ^a				
	1	2	3	5	6
Date	12/06/86	12/07/86	12/07/86	12/15/86	12/15/86
Start time	1339	0945	1455	0920	1145
Finish time	1455	1100	1605	1030	1255
Duration (minutes)	76	75	70	70	70
Average soil feed rate (tons/hr)	2.82	3.64	3.71	5.22	6.31
Soil treated (tons)	3.6	4.6	4.3	6.1	7.4
Kiln max temp (°F)	1661	1449	1642	1624	1418
Kiln min temp (°F)	1630	1332	1440	1391	1315
Kiln avg temp (°F)	1645	1377	1552	1485	1355
Kiln min pressure (in. H ₂ O)	-9.64 ^b	-0.37	-0.44	-0.43	-0.39
Kiln max pressure (in. H ₂ O)	-0.15	0	-0.14	-0.36	-0.23
Kiln avg pressure (in. H ₂ O)	-2.1	-0.2	-0.25	-0.39	-0.33
SCC ^c max temp (°F)	2184	2184	2187	2168	2118
SCC ^c min temp (°F)	2161	2137	2140	2090	2081
SCC ^c avg temp (°F)	2171	2159	2174	2113	2097
SCC ^c min pressure (in. H ₂ O)	-2.15	-2.27	-2.37	-2.70	-2.51
SCC ^c max pressure (in. H ₂ O)	-1.68	-1.62	-1.95	-2.36	-2.12
SCC ^c avg pressure (in. H ₂ O)	-2.00	-1.92	-2.09	-2.51	-2.26
Avg stack oxygen concentration (percent)	3.68	5.22	5.68	10.58	5.41
Avg combustion efficiency CO ₂ (percent)	Invalid ^d	99.9584	99.9481	99.9585	99.9811
CO (percent + CO ₂ percent)					

a. Test Burn 4 is not shown because of similarity to Test Burn 3 and the samples were not analyzed.

b. During the test burn the kiln pressure normally operated between zero and - 1 inch of water except for two readings: -8.4 inches at 0715 and -9.64 inches at 0745, which were both ahead of the stack sampling period. Plotted data is shown in Appendix H.

c. SCC means secondary combustion chamber.

d. The combustion efficiency for Test 1 was invalid due to a CO₂ monitor failure. The instrument was repaired and subsequent tests are valid.

SOIL FEED RATE vs. ELAPSED TIME

THREE POINT AVERAGE

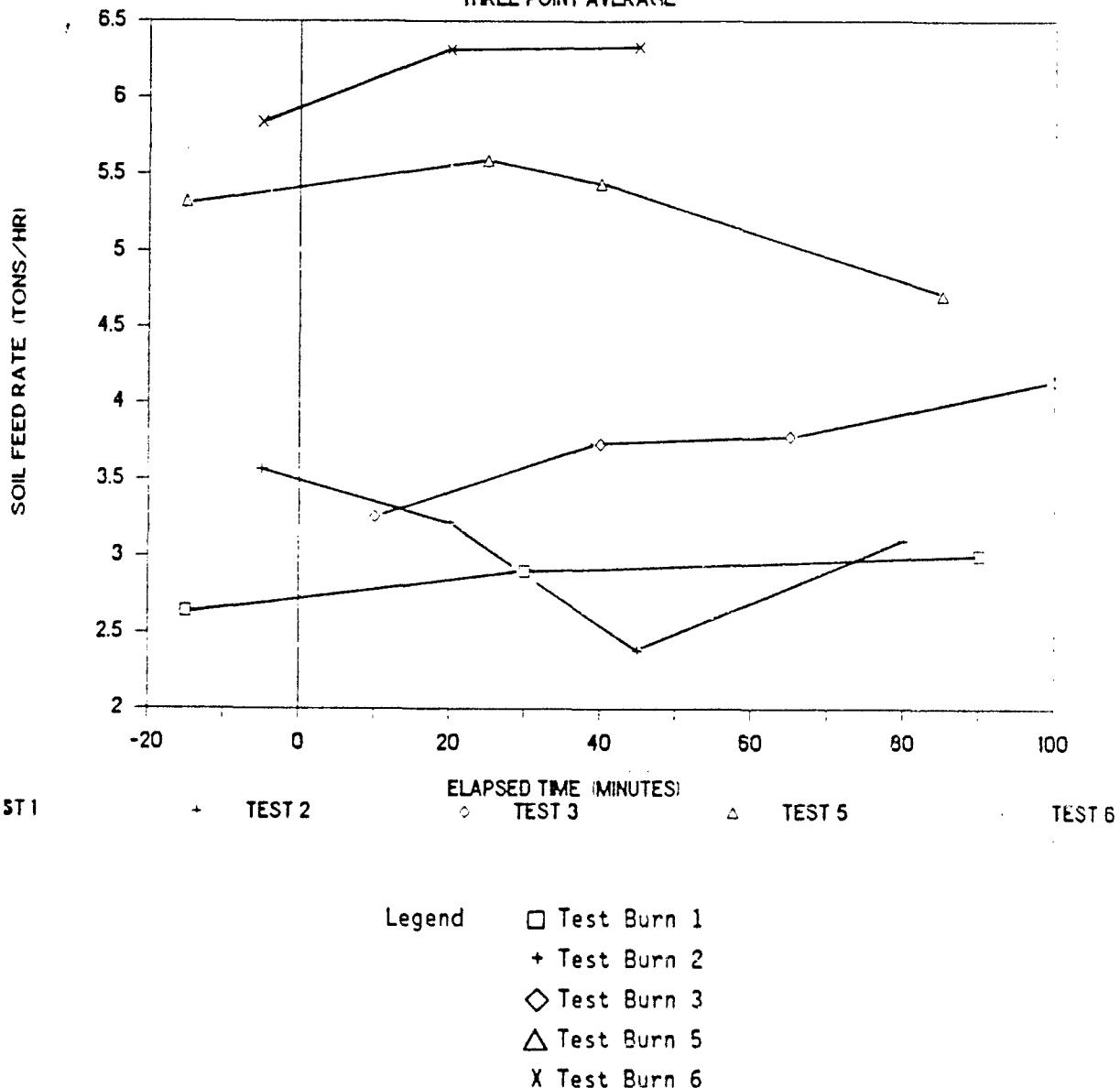


Figure 32. Plot of soil feed rate versus elapsed time for each test burn.

KILN TEMPERATURE vs. ELAPSED TIME

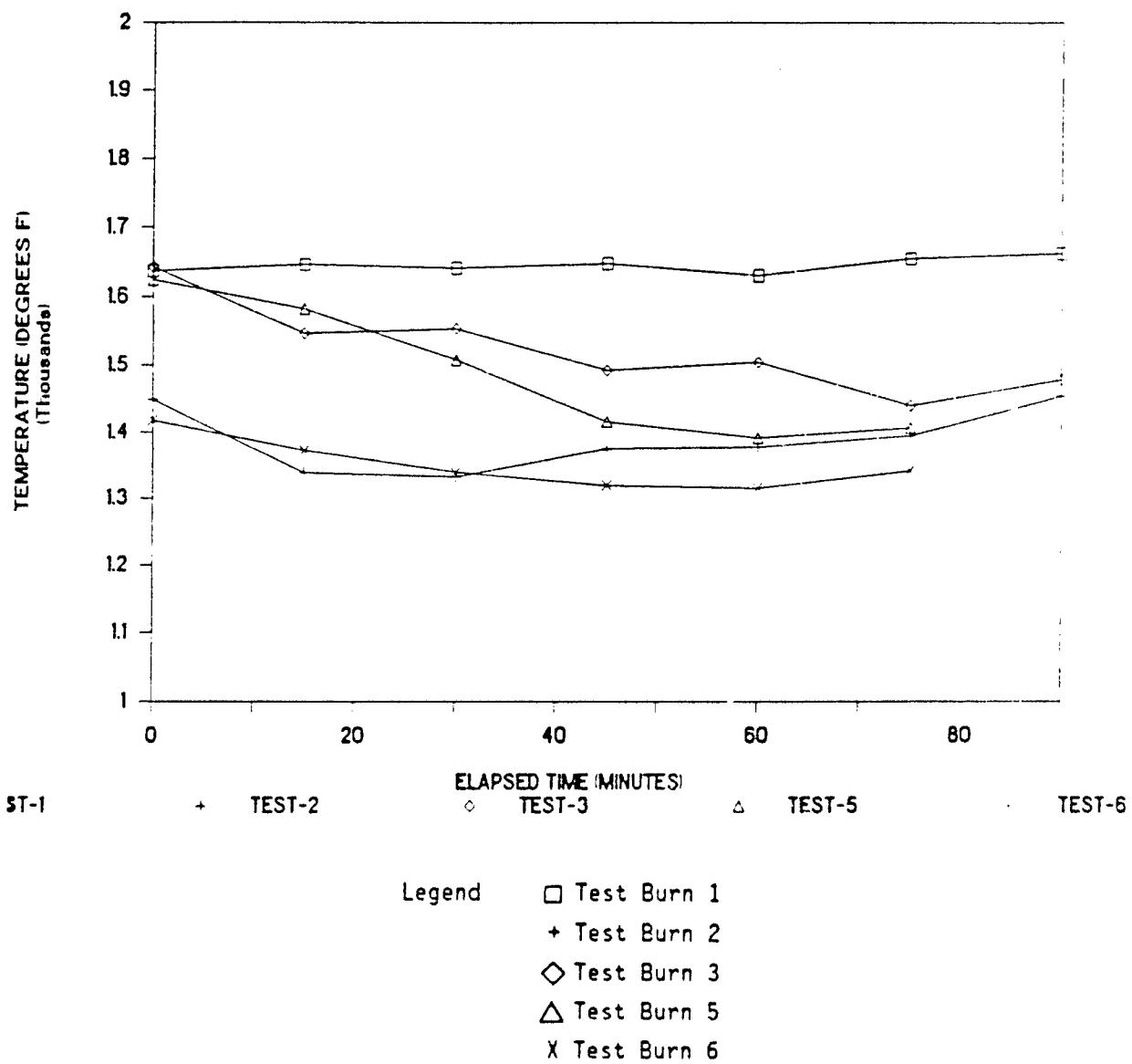


Figure 33. Plot of kiln temperature versus elapsed time for each test burn.

SCC TEMPERATURE vs. ELAPSED TIME

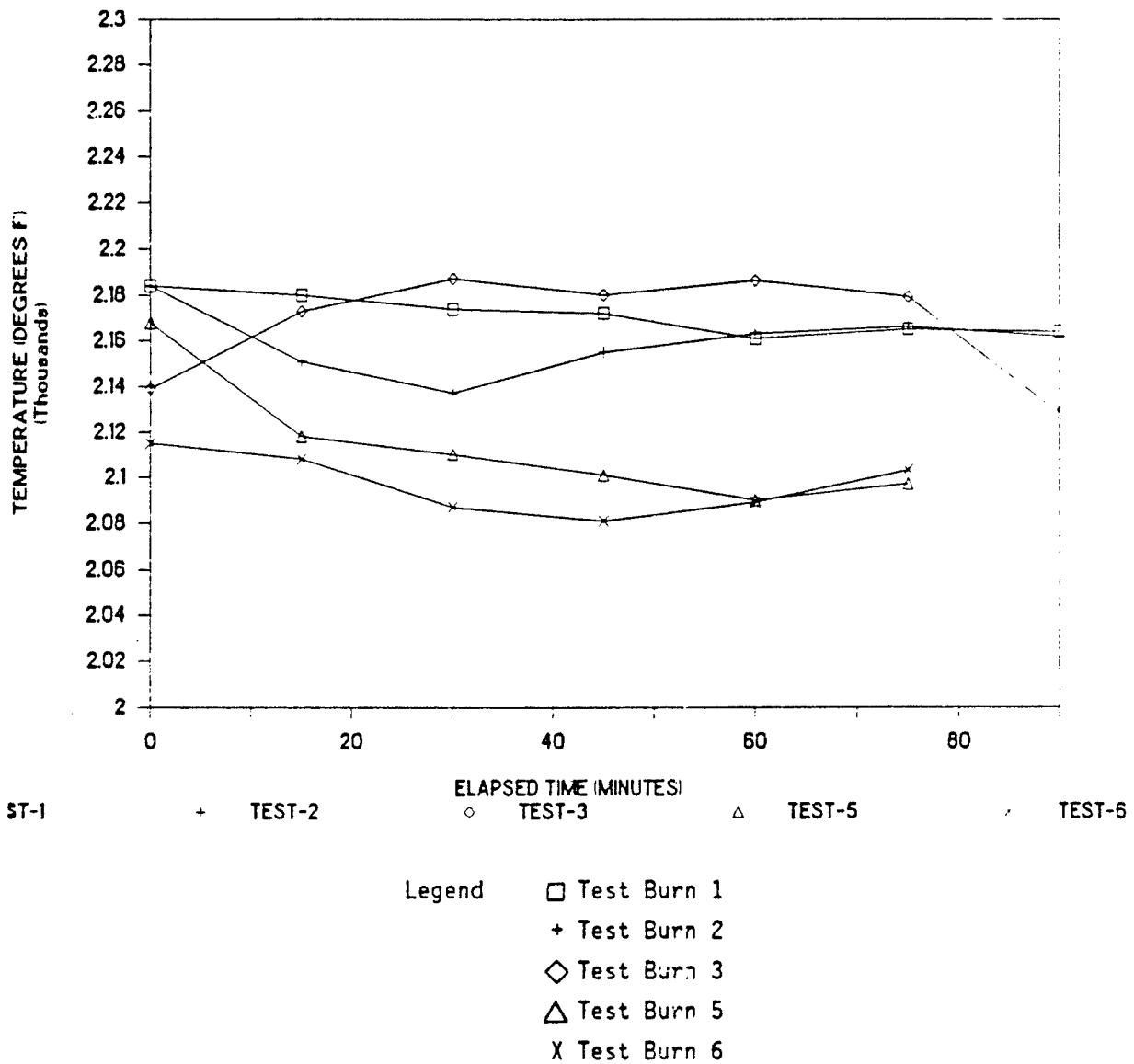


Figure 34. Plot of secondary combustor temperature versus elapsed time for each test burn.

Table 7 lists the critical instruments used, their ranges, and their accuracy.

Table 7. Instrument range and accuracy for critical measurements

Instrument	Range	Accuracy (percent of range)
Kiln outlet temperature	0 to 3000°F	±1.8
SCC outlet temperature	0 to 3000°F	±1.8
Kiln outlet draft	0 to 2 inches H ₂ O	±2
SCC outlet draft	0 to 2 inches H ₂ O	±2
Stack CO monitor	0 to 50 percent by volume	±1
Stack CO ₂ monitor	0 to 50 percent by volume	±2
Stack O ₂ monitor	0 to 25 percent by volume	±1
Soil weigh hopper	0 to 15,000 lb	±2

Test Burns 2 and 3 were run at nearly identical average feed rates of 3.6 ton/hr and 3.7 ton/hr, respectively. Tests 5 and 6 were designed to test the incinerator's upper operating envelope; therefore, 5.2 ton/hr and 6.3 ton/hr were used for those tests.

The average kiln temperature for all five test burns (Test Burns 1, 2, 3, 5, and 6) was 1483°F, based on DAS log readings taken at 15-minute intervals. Test Burn 1, which had the lowest average soil feed rate (2.8 tons/hr), had the highest average kiln temperature (1645°F); whereas, Test 6, which had the highest average soil feed rate (6.3 ton/hr), had the lowest average kiln temperature (1355°F). Test Burns 2 and 6 had similar kiln temperature conditions with averages of 1377 and 1355°F, respectively. The data in Table 6 show that the kiln temperature stayed within the permit operation conditions of 1200-1800° (Table 5) while contaminated soil was being treated.

The average SCC temperature for all five test burns was 2142°F, which is very close to the permit nominal operating condition of 2150°F (Table 5). However, the plotted curves in Figure 34 show a range of test run profiles with Test Burn 2 being closest to the planned nominal condition with an average temperature of 2159°F. Test Burns 1 and 3 had the highest average SCC temperatures at 2171 and 2174°F, respectively. Test Burns 5 and 6, which had high average soil feed rates (5.2 and 6.3 ton/hr, respectively), also had low average SCC temperatures (2113 and 2097°F, respectively). The plotted data in Figure 34 show the SCC temperature during Test Burn 5 was below the permit minimum limit of 2100°F (Table 5) for about 30 minutes with the lowest temperature only 10°F below this limit. The SCC temperature during Test Burn 6 was below the limit for about 50 minutes with the lowest temperature only 19°F below the limit. Test Burns 5 and 6 were relatively short, served as a means to gather data for high feed rates, and had small deviations; therefore, rather than terminating the test, the soil feed was continued. In each case the SCC temperature increased by the end of the test with the temperature in Test Burn 6 returned above the 2100°F limit.

Test Burns 5 and 6 were the most conservative for several reasons. The soil feed rates were higher and thus more difficult to process. The kiln temperatures and soil residence times were both lower, making the thermal desorption process less effective. The SCC temperatures were lower and, thus, more likely to cause incomplete combustion.

Despite the lower temperatures and higher soil feed rates during Test Burns 5 and 6, soil cleanup occurred and none of the principal organic hazardous constituents (POHCs) were detected in the stack gas. A more complete discussion of the stack gas analysis is presented in Section VI.B.

Three equipment/instrument failures caused critical parameters to deviate from the permit operating limits. The first case had other monitors to show the process had not changed and hence was

benign. The other two cases occurred when no contaminated soil was being processed; hence, the deviations were benign in effect. For the record, these cases are discussed in the following paragraphs.

On December 6, during Test Burn 1 at approximately 1330, the carbon dioxide detector failed. This caused erroneous calculations of the combustion efficiency between 1330 and 1415 (the invalid data were omitted and replaced with a dashed line in the plot in Appendix M, Exhibit 1). The test had begun before the instrument failure was detected. Once the failure was detected, the monitor was repaired and the test continued. Because neither the carbon monoxide concentration nor any other critical operating parameter had changed or instrument had failed, it was clear that only the carbon dioxide monitor had failed; therefore, the interlock was overridden and the test continued. Onsite EPA Region IV staff were told of this situation as soon as it was recognized and were informed of the replacement as it was completed. Subsequent testing at the higher feed rates demonstrated the ability of the carbon monoxide and the carbon dioxide monitor to successfully track the combustion efficiency.

On December 7, at approximately 1430, the SCC temperature fell to 2060°F. That temporary fluctuation (shown in the plot in Appendix M, Exhibit 2) was caused by burner flameout condition. The burner was quickly reignited and temperature was restored to its normal operating condition before initiation of Test Burn 3, which began at 1455.

On December 15, the SCC temperature fell below the prescribed value of 2150°F between 0500 and 0615 (shown in the plot in Appendix M, Exhibit 3). That event was caused by a temporary flameout condition during the incinerator warm-up period before Test Burns 5 and 6. No soil was being fed to the incinerator at that time.

4. Health and Safety Monitoring Results

Use of Class C protective clothing and respiratory equipment by personnel functioning inside the contamination zone followed the requirements presented in Section III.C.1. Results of the industrial hygiene monitoring during the activities for the verification test burns, as specified in the health and safety plan (Appendix G), are summarized in the following subsections (see also Appendix N for the full report).

a. Dust Monitoring

Baseline dust activity measurements by use of a direct reading monitor were initiated on November 15, 1986. Up to the first day of soil disturbance in the contaminated zone, dust levels were shown to be 0-0.02 mg/m³. A concentration of 0.02mg/m³ is commonly found in areas with no activity.

Excavation of the contaminated grids commenced on December 4. A direct reading monitor showed readings up to 0.027 mg/m³ with the two highest readings caused by a passing truck. A preweighed filter cassette and air sample pump were used to measure the operator's breathing zone in the excavator cab. Results from the analysis of the filter cassette were 0.0325 µg/L. The same low results were obtained from the filter cassette for the excavator operator on December 5.

Direct reading monitor measurements showed dust concentrations of 0.023 mg/m³ or less during the test burn days on December 6 and 7. Analysis of a filter cassette showed a dust concentration less than 0.007 µg/L (detection level) at the shredder location on December 6. A similar result was obtained for December 7.

b. 2,3,7,8-TCDD Monitoring

XAD tube samples were taken at the shredder controller box during the test burn operations on December 6 and 7. No 2,3,7,8-TCDD was detected at a detection limit of 5 ng/m³. The operator wore Level "C" protection (powered air-purifying respirator).

c. Heat Stress Monitoring

One Versar employee performing sampling tasks showed signs of heat stress on the first test burn day. This individual's tasks were revised on the next day. Operating personnel showed no signs of heat stress. The cool December weather and extensive rains provided considerable relief.

5. Waste Storage and Disposal

a. Treated Soil

The approximate 100 tons of treated soil from the contaminated feedstock was stored in a known clean area (proximity of Plot AD-78 in Area A) to await EPA Region IV authority to place the soil within excavated areas of the NCBC site. The soil was placed on plastic material to prevent possible leaching to the soil beneath.

b. Other Solids

Other potentially contaminated solids materials, such as protective clothing and sampling items, were placed in polyethylene bags and stored within the contamination zone for subsequent processing through the incinerator.

c. Liquids

Potentially contaminated liquids, initially stored in tanks and samples, were collected for analysis. In each case, the results showed the effluent to meet the requirements of the state POTW Permit (Appendix D, Exhibit 3), so disposal was made through the POTW line. The boiler blowdown water was also fed to the POTW; however, the water was analyzed before disposal to show a pH ≤ 9.5 to satisfy requirements of the state permit.

6. Construction Site Certification

The EPA RD&D permit for the NCBC demonstration testing required submitting a construction certification to show the test was in compliance with the permit (Volume IV). A copy of the certification is in Appendix O.

D. SAMPLING

1. Methods/Protocols

The Versar sampling methods/protocols used during the MWP-2000 incinerator verification test burns at NCBC are summarized in the following subsections. For further details, see Appendix K.

a. Feedstock Soil

Samples of feedstock soil were collected from the conveyor as the soil was transferred from the weigh hopper, as shown in Figure 35. Grab samples were generally obtained every 20 minutes during the test, starting about 10 minutes prior to initiation of the test (to take into account the residence time of the soil in the feed hopper). Individual aliquot samples were obtained by taking nine equal volume grab samples from different locations on the conveyer belt. Each aliquot sample consisted of 48 ounces, which was measured volumetrically (i.e., three 16-ounce jars were filled and each jar required three scoops of soil that was obtained with a sample trowel). Collected sample aliquots were placed in a wheelbarrow, lined with clean aluminum foil and composited after all aliquots were taken. The composited samples were then placed in appropriate sample jars.



Figure 35. View of feedstock soil sample being taken.

b. Treated soil (kiln soil sample)

Grab samples of treated soil in the kiln were obtained using a 1 1/2-inch diameter pipe to grab soil samples as the soil exited the kiln but before it fell into the ash drag. Collection of those samples is shown in Figure 36. A sight glass was removed to gain access to the inside of the kiln. Sample collection began generally 30 to 60 minutes (depending on soil feed rate) after the test had begun. A representative composite sample was prepared by homogenizing the individual sample aliquots, which consisted of several equal volume grab samples after they have been allowed to cool. Each aliquot sample consisted of 32 ounces, measured volumetrically. Collected samples were placed in a clean stainless steel bucket, composited after all test aliquots were taken, and put in appropriate sample jars. The stainless steel bucket remained covered when samples were not being collected.

c. Treated Soil (ash drag)

Grab samples of treated soil from the ash drag were obtained using a small clean trowel to catch samples as the soil fell off of the ash drag conveyor into the ash drag bin. Care was taken to collect nine equal volume grab sample aliquots at various locations in the soil stream. Sample collection began generally 30 to 60 minutes (depending on soil feed rate) after the test had begun. Each aliquot sample consisted of 48 ounces that were measured volumetrically (i.e., three 16-ounce jars were filled and each jar required three scoops of soil that was obtained with a sample trowel). A representative composite sample was prepared by homogenizing all sample aliquots at the end of each test. Collected sample aliquots were placed in a clean stainless steel bucket, composited, and put in appropriate sample jars. The stainless steel bucket remained covered when samples were not being collected.

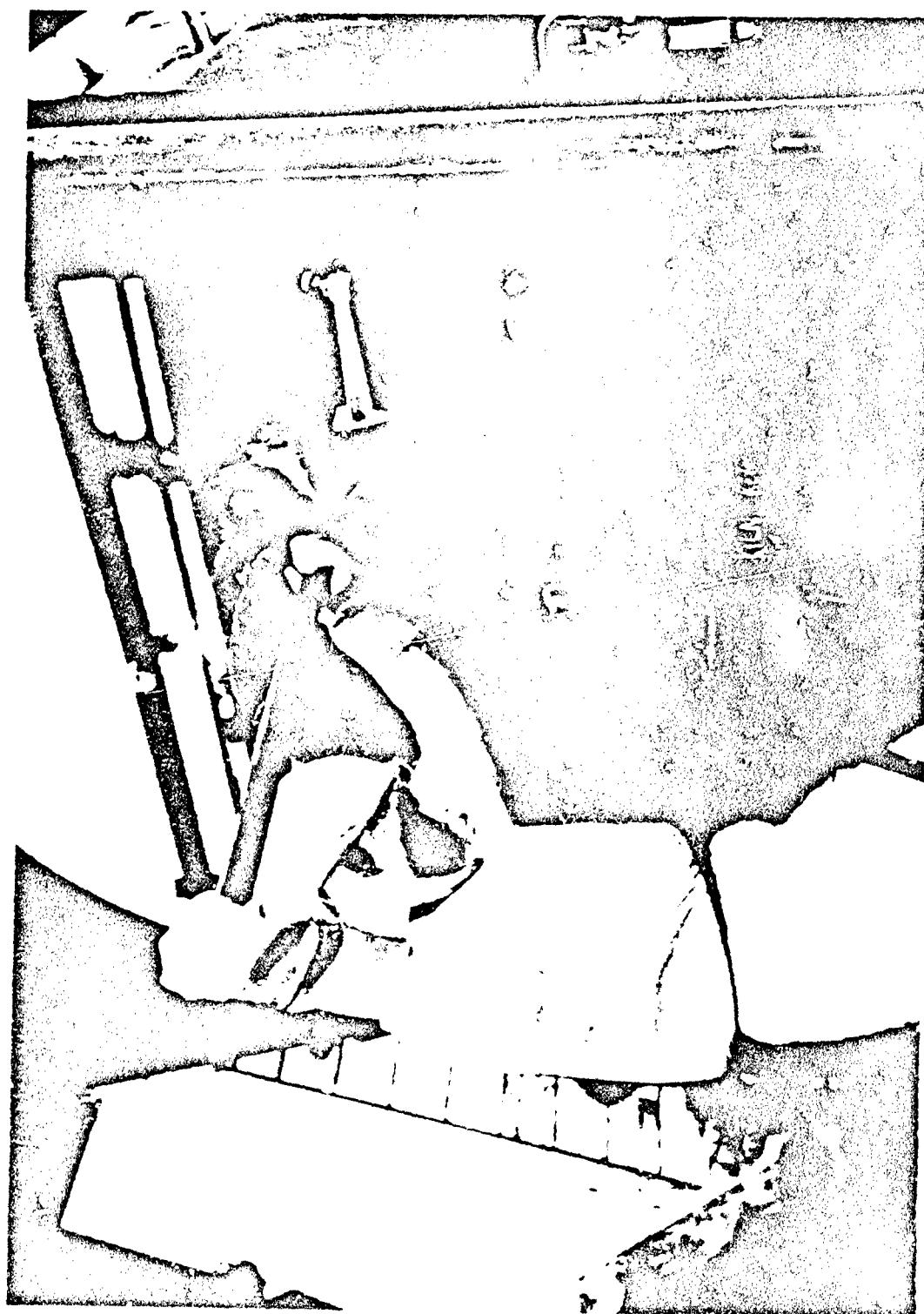


Figure 36. View of kiln solids sample being taken.

d. Stack Gas

During all test, MM5 and VOST sampling trains were used to sample for potential principal organic hazardous constituents (POHCs) and products of incomplete combustion (PICs). The MM5 and VOST sampling trains were identical for each test and their configurations are shown schematically in Figures 37 and 38 for MM5 and VOST trains, respectively. The VOST apparatus is shown in Figure 39. A photograph of the sampling crew on the incinerator stack is shown in Figure 40.

The MM5 sampling trains and their operation were in accordance with EPA approved procedures. (Reference 27). An alkaline solution (sodium hydroxide) was used in the second impinger to trap acid vapors and to quantify the HCl. One of the requirements of the method was that no grease be used for sealing joints in the train. Viton O-rings were used to seal all joints prior to and including the first impinger.

The filter in the MM5 sampling train was used to collect particulate in the stack gas sample. This sample was used to quantify: (1) the weight of particulate captured and (2) analysis of semivolatiles. The procedures used to accomplish the above test objectives for the particulate filter were:

- Step 1: Dry filters in desiccant box for a minimum of 24 hours
- Step 2: Preweigh each filter and record weight
- Step 3: Use filter for MM5 test
- Step 4: Dry filter for 24 hours in desiccant box
- Step 5: Weigh filter
- Step 6: Dry filter in desiccant box for an additional 8 hours
- Step 7: Reweigh filter to confirm no additional weight loss
- Step 8: Seal filter in sample container and ship for analysis.

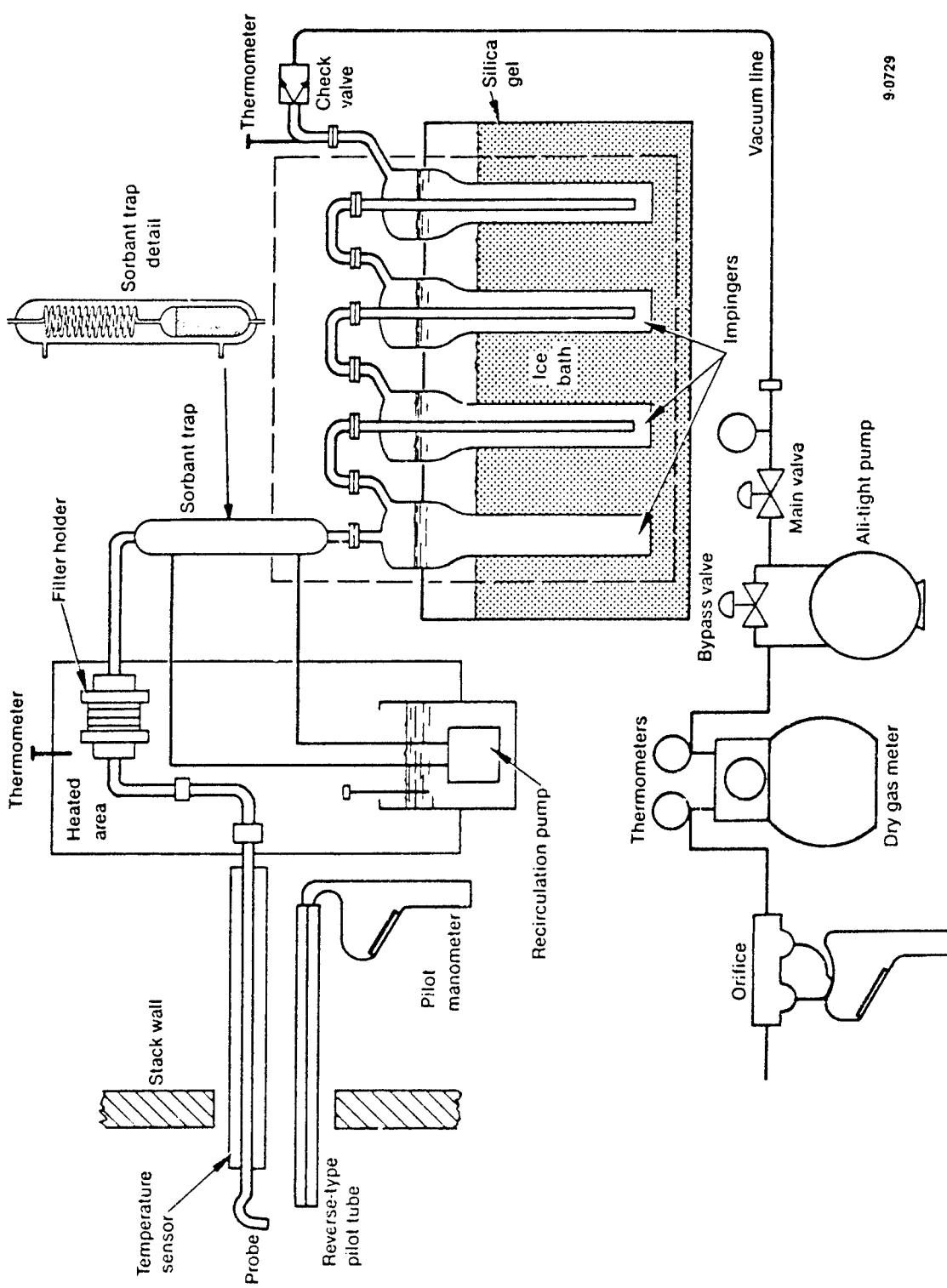
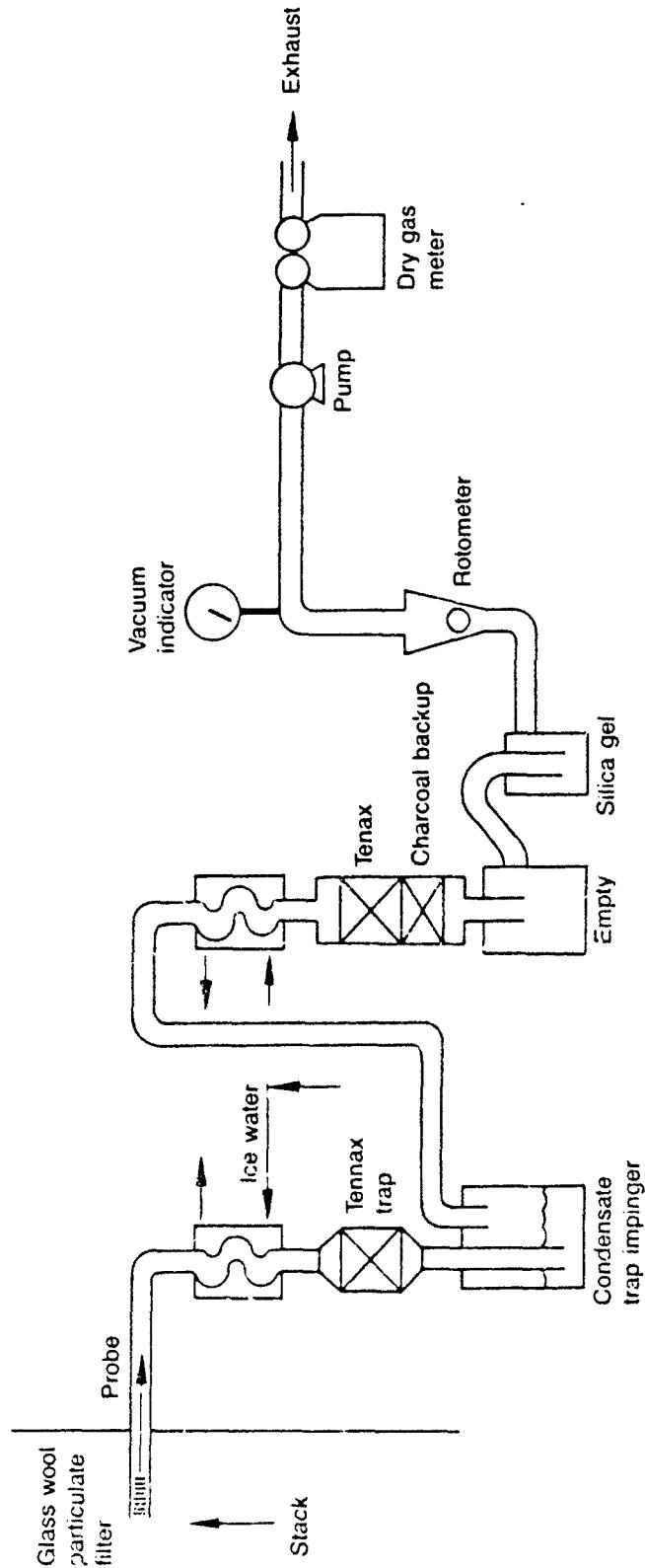


Figure 37. Schematic of modified method 5 sampling train (MM5).



0-6592

Figure 38. Schematic of Volatile Organic Sampling Train (VOST).

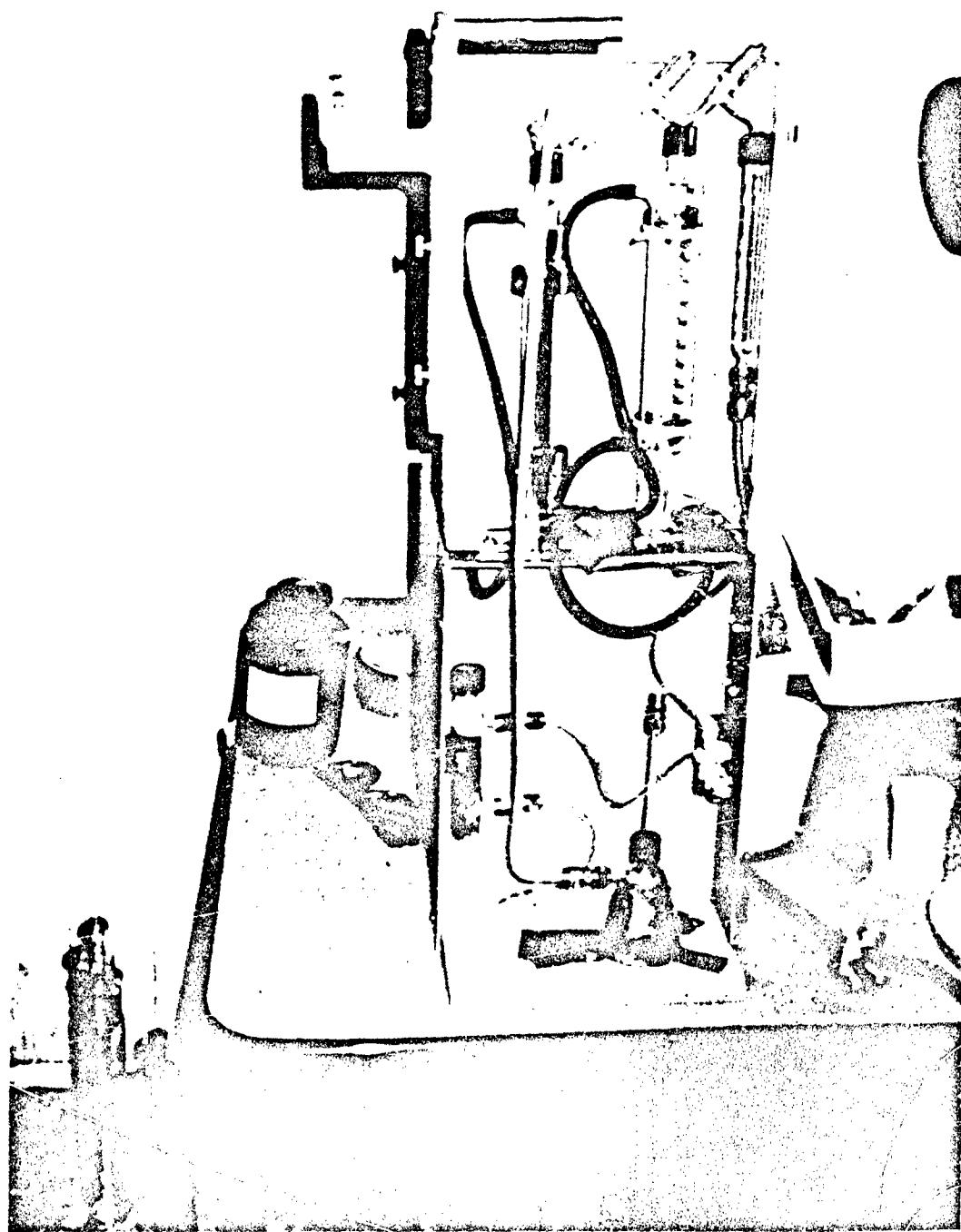


Figure 39. View of VOST apparatus.

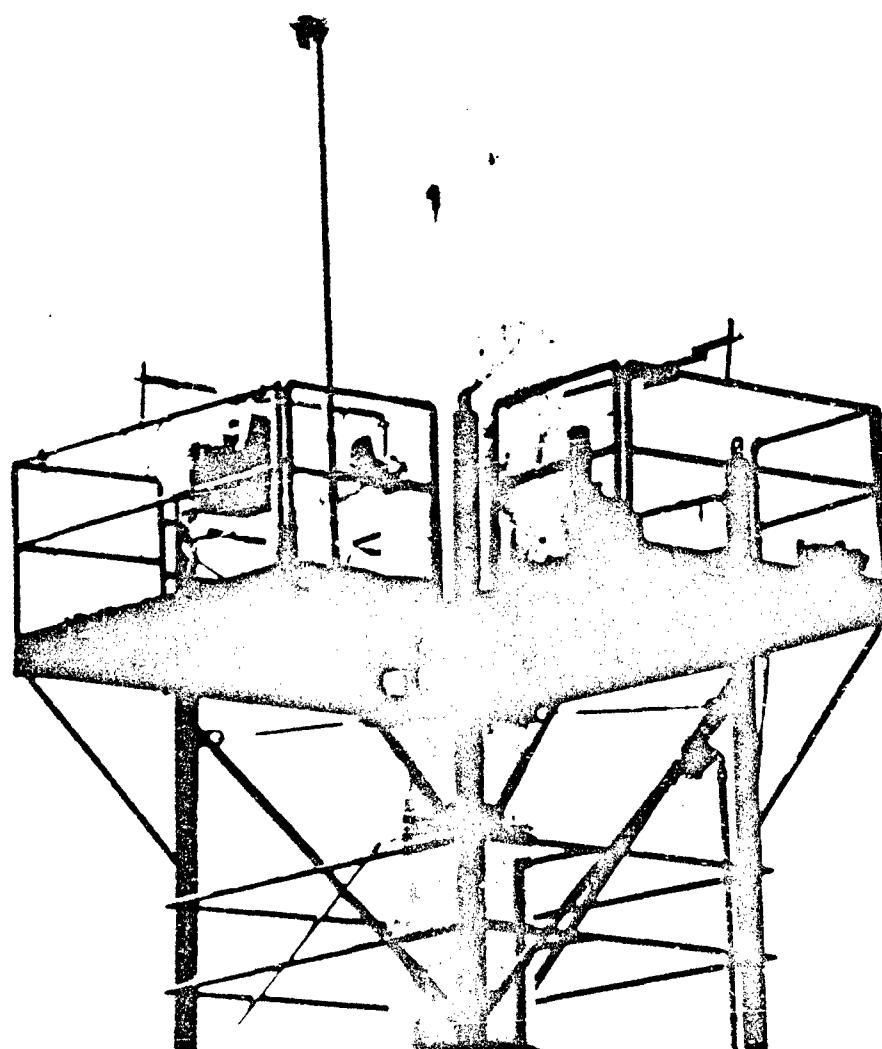


Figure 40. View of sampling crew on the incinerator stack.

All drying was performed at ambient temperatures in a 1 cubic-foot drying box constructed of stainless steel and glass. The drying box was located inside the sample trailer, which was maintained at a room temperature of nominally 70°F. Because chemical analysis of the particulate fraction on the filter was to be restricted to semivolatiles, drying the filter in the desiccant box should not volatilize any of the compounds of interest since the temperature was never increased above ambient conditions. Approximately 500 grams of silica gel were replaced when a color change from blue to pink was observed. After the filter was reweighed, it was placed in a petri dish that was sealed with tape.

The sampling location and number of traverse points for MM5 sampling was determined after the presurvey according to procedures established in EPA Reference Method 1 (40 CFR 60, Appendix A). Based on a stack diameter of 30 inches and the fact that the sampling ports were greater than eight stack diameters downstream of any flow disturbance, six sampling point locations were established on two perpendicular stack cross sections. Stack gas moisture and velocity were determined according to the MM5 sampling using the procedures established in EPA Reference Method 4 (40 CFR 60, Appendix A). Stack gas molecular weight was determined concurrently with the MM5 sampling using procedures established in Reference Method 3 (40 CFR 60, Appendix A).

The VOST sampling train basically consisted of a system designed to draw sample gas at a flow rate of 1 liter/minute through two traps in series for a period of one hour. The first trap contained Tenax^R and was preceded by a gas cooler/condenser, which is followed by an impinger for condensate collection. The second trap contained a section of Tenax^R and a section of charcoal just downstream of the impinger. The purpose of the second trap was to collect very volatile POHCs (e.g., vinyl chloride), which will break through a Tenax^R trap.

Before all tests, the MM5 gas metering device was calibrated against a positive displacement wet test meter. Temperature sensors were calibrated against an ASTM mercury-in-glass thermometer, and/or calibrated in an ice bath and a boiling water bath. The aneroid

barometer was checked against a mercury column barometer. The pitot tubes were constructed according to the design criteria of EPA Reference Method 2 (40 CFR 60, Appendix A). In addition, the S-type pitot tubes were calibrated in a wind tunnel. Before the test, the VOST gas metering device was calibrated against a positive displacement wet test meter. For ease of reference as well as data collection and reduction, actual calibration and in-field data logs were maintained on a Compaq^R computer.

e. Effluent Neutralization Tank

Effluent neutralization tank samples were collected via a sample port located immediately after the quench recirculation pumps. Prior to sample collection, the port was emptied of any potentially stagnate liquid. Equal volumes of each grab sample (3 pints) were obtained and placed in a clean 5-gallon glass jar (iced) in which the samples were composited. At all times (except when filled or emptied), the jar opening was covered with clean aluminum foil to prevent cross contamination. After the last grab sample was obtained, appropriate sample bottles were filled directly from the glass container and sealed.

f. Quench/Scrubber Fines

Quench/scrubber fines samples were obtained from the end of the discharge line that dumps the fines into the settling tank. The fines were concentrated in a Lamella clarifier, which is part of the effluent neutralization tank. Grab samples (2 pints collected in appropriate sample jars) were obtained at the end of each test.

g. Boiler Blowdown

Boiler blowdown samples were obtained via a sample port located on the waste heat boiler. Prior to sample collection, the port was emptied of any potentially stagnate liquid. Each equal volume grab sample (2 pints) was obtained and placed in a clean 5-gallon glass jar in which the samples were composited. At all times except when filled or

emptied, the jar opening was covered with clean aluminum foil to prevent cross contamination. After the last grab sample was obtained, sample bottles were filled directly from the glass container and sealed.

h. Water Discharge to POTW

After all six tests were completed, water from the effluent neutralization tank was pumped through activated carbon beds, then into a POTW holding tank. A water sample (4 gallons) was obtained from a sample tap located on the line between the carbon beds and the POTW holding tank. In compliance with the State water discharge permit, no water was released to the POTW pending review of the water analysis data.

i. Caustic Water

Caustic water makeup to the air pollution control scrubber was sampled to determine potential sources of cross contamination. The protocol for obtaining the caustic water sample is detailed in the quality assurance program plan, which is part of the Sampling and Analysis Plan (see Appendix K).

j. Blanks

A background water sample (1 gallon) was obtained from a water tap used to provide feed water to incinerator operations. The individual sample bottles were filled directly form the water tap in the field. The protocol for obtaining the blank gas sample is detailed in the quality assurance program plan, which is part of the Sampling and Analysis Plan (see Appendix K).

k. Sampling Frequency and Schedule

The duration of each test was nominally 2 hours, which was the time required to obtain 60 minutes of continuous stack gas samples with the MM5 and VOST trains.

1. Sample Containerization, Preservation, and Holding Times

All samples collected were placed in their appropriate containers and preserved by procedure (with ice, if required). They then were analyzed within the time constraints consistent with procedures summarized in EPA 600/4-79-020 (Reference 28) or as indicated by specific analytical methods such as in EPA SW-846 (Reference 26)

m. Sample Tracking and Management

All sample containers were labeled with the upper portion of Versar's standard three-part label. The duplicate label was affixed to containers in which the sample jars were packaged. The lower portion of the sample label was placed (as appropriate) into the field logbook as a cross check mechanism for sample identification. For ease of identification, the sample numbers assigned to some samples used the following convention:

<u>Sample No.</u>	<u>Description</u>
FS-N	Feedstock soil
KS-N	Kiln soil
AD-N	Ash drag soil
ENT-N	Effluent neutralization tank
SF-N	Quench/scrubber fines
BB-N	Boiler water blowdown
BS-1	Blank soil sample

where N = test number. These sample points are identified in Figure 22. All other samples obtained were traced using an assigned Versar sample number.

All samples were tracked using Versar's standard chain of custody form. Custody of the samples began at the time of sample collection and was maintained by the sampling team supervisor until samples were relinquished for shipment to ITAS in Knoxville, Tennessee, for analysis.

2. Material Samples

Feedstock, kiln, and ash drag soil samples were collected at approximately 20-minute intervals during each of the test burns (Table 8). The number of samples of each type varied between five and seven for the test burns. Feedstock soil sampling generally began about 10 minutes before each test began. This 10-minute advance was needed to account for the residence time of the soil in the feed hopper/conveyor feed system. Treated soil sample aliquots were obtained about every 20 minutes for the kiln soil and ash drag samples. Depending on the feed rate of the soil, termination of sampling was extended after the end of the test burn for about 20 to 30 minutes. This extension accounted for the residence time of the soil in the kiln. Figures 35 and 36 show feedstock and kiln solids samples being taken.

Boiler blowdown and effluent neutralization tank aliquot samples were taken every 20 minutes (a total of six grab samples were obtained) during the duration of each test by collecting equal volume sample aliquots and placing them in clean 5-gallon glass jars. At the end of each test, the samples were composited and placed in appropriate sample jars. The quench/scrubber fines grab sample was collected at the end of each test. The blank water sample was obtained prior to the tests. As described earlier, the grab sample of water destined to the POTW was obtained after all six tests were completed.

Table 8. Feedstock and treated soil sample collection times

<u>Test Burn (Date)</u>	<u>Soil Sample^a</u>		
	<u>Feedstock</u>	<u>Kiln</u>	<u>Ash Drag</u>
1-(12-6-86)	1320 hr	1435 hr	1438 hr
	1342	1512	1507
	1420	1531	1531
	1443	1550	1555
	1518	1610	1615
	1543	1631	1638
	1616		
2-(12-7-86)	0956	1022	1015
	1015	1037	1030
	1037	1055	1050
	1055	1117	1114
	1115	1125	1124
		1152	1150
3-(12-7-86)	1455	1526	1529
	1515	1547	1544
	1537	1607	1605
	1555	1628	1620
	1615	1650	1648
	1635	1709	1707
	1657	1728	1727
5-(12-15-86)	0910	0955	0950
	0930	1013	1010
	0955	1033	1030
	1010	1053	1050
	1030	1113	1120
	1050	1130	1133

Table 8. (continued)

<u>Test Burn (Date)</u>	<u>Soil Sample^a</u>		
	<u>Feedstock</u>	<u>Kiln</u>	<u>Ash Drag</u>
6-(12-15-86)	1140	1217	1215
	1200	1237	1235
	1220	1257	1255
	1240	1317	1315
	1300	1337	1335
	1320	1357	1355

a. Sample collection data for Test Burn 4 on December 8, 1986, are not included because samples were not analyzed.

Table 9 summarizes the sample times and in-field data obtained during the six separate stack gas sampling episodes. Detailed MM5 and VOST test data sheets are provided in Appendix P. As mentioned earlier, the duration of each test was based on the time required to obtain the MM5 and VOST samples. Accordingly, the sampling frequency and schedule for obtaining the other samples were based on the nominal 2-hour test duration.

3. Ambient Air Samples

During the verification test burns, two activities required ambient air monitoring--soil excavation and incineration of contaminated soil. Two different types of ambient air samplers were used for air monitoring: one was a polyurethane foam (PUF) sampler (General Metal Works Model PS-1), which is described in detail in the sampling plan (Appendix K), and the other is a standard high-volume (SHV) air sampler, which was operated at a flow rate of 40 cfm. Besides collecting particulates, the PUF sampler is designed to sample for organochlorine vapor compounds. The sampling head of a PUF sampler is shown in Figure 41 and the sampling head for a standard high-volume air sampler is shown in Figure 42.

Versar ambient air sampling was conducted during the contaminated soil excavation and test burn activities as follows:

<u>Dates of Sampling</u>	<u>Site Activities</u>
12-4	Excavation and preparation of soil
12-5	Excavation and preparation of soil
12-6	Test Burn 1, excavation of soil
12-7	Test Burns 2, 3
12-8	Test Burn 4
12-11 through 14	Soil drying
12-15	Test Burns 5, 6

Table 9. Summary of stack test (modified method 5 and VOST) operating data

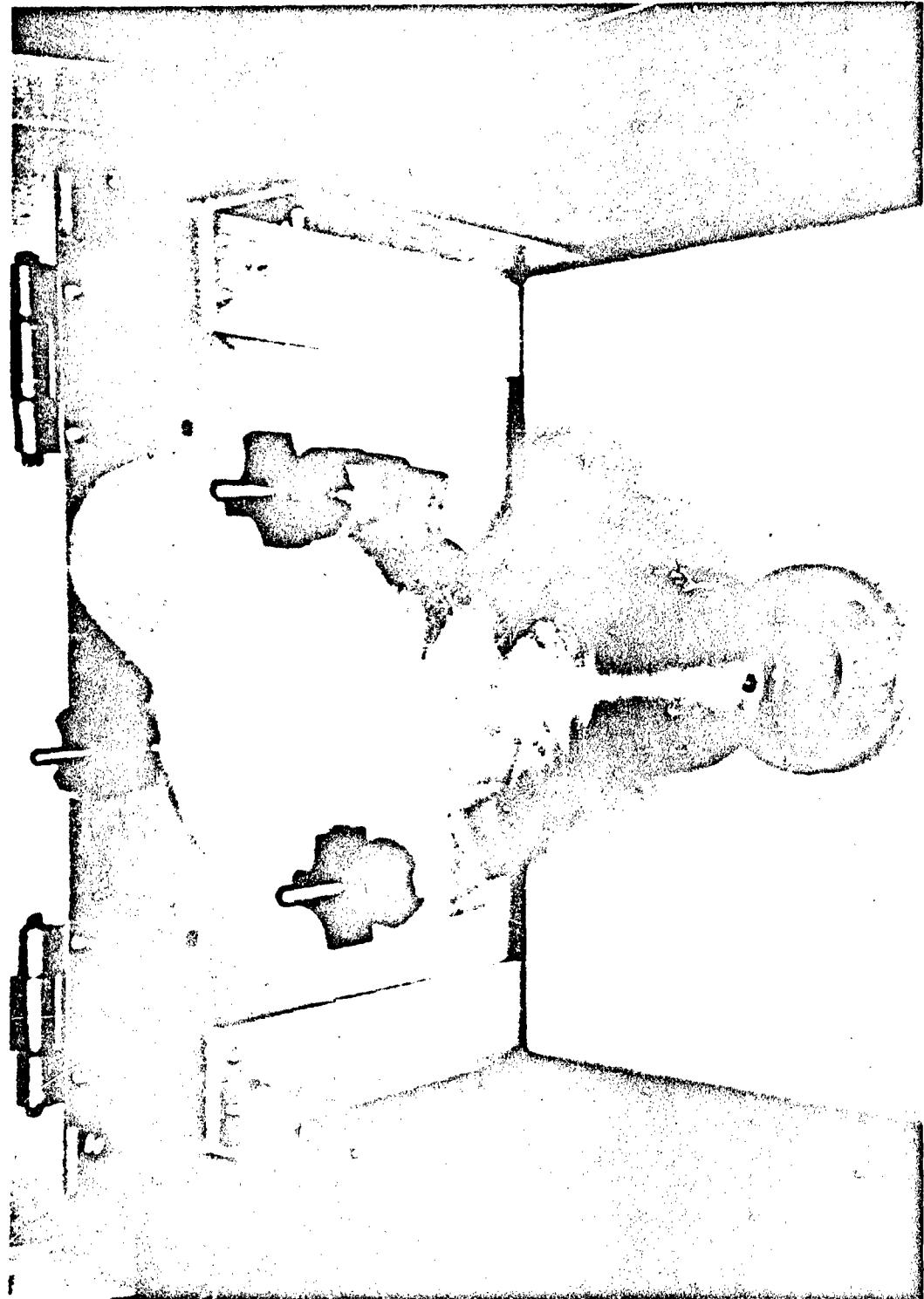
Parameter	Units	Test Burn ^a				
		(12-6)	(12-7)	(12-15)	(12-15)	(12-15)
1. Time						
Start	hour	1339	945	1455	920	1145
Finish	hour	1456	1100	1605	1030	1255
Duration of sampling	min.	60	60	60	60	60
2. Total number of sampling points	N.P	12	12	12	12	12
3. Meter calibration factor	Y	0.994	1.994	0.994	0.994	0.994
4. Orifice calibration factor	Ha	1.613	1.613	1.613	1.613	1.613
5. Nozzle specification						
Diameter	in ²	0.375	0.25	0.25	0.25	0.25
Area	ft ²	7.67E-04	3.41E-04	3.41E-04	3.41E-04	3.41E-04
6. Pitot tube coefficient	Cp	0.801	0.801	0.801	0.801	0.801
7. Average orifice pressure drop	in H ₂ O	2.229	0.973	0.952	0.828	1.093
8. Volume of dry gas sampled	ft ³	51.976	35.278	35.955	31.726	38.328
9. Average gas meter temperature	°R	559.5	555.8	558.9	553.7	563.0
10. Barometric pressure	in Hg	30.46	30.25	30.25	30.26	30.26
11. Static stack pressure	in H ₂ O	-0.42	-0.38	-0.38	0.56	0.52
12. Absolute stack pressure	in Hg	30.43	30.22	30.22	30.30	30.30
13. Volume of gas sampled (standard)						
Modified Method 5	dscf	49.865	33.743	34.141	30.452	36.205
VOST	liter	50.326	50.999	56.650	46.836	64.726
14. Volume of water collected in impingers and silica gel	mL	663	692	679	839	1015
15. Volume of water collected based on saturated conditions	mL	1022	643	678	837	1046
16. Volume water vapor condensed in impingers	scf	29.75	32.15	31.44	39.07	47.21
17. Volume water vapor condensed in silica gel	scf	1.47	0.45	0.54	0.43	0.57
18. Percent moisture by volume	percent	30.50	49.13	48.37	56.46	56.89
19. Percent moisture by saturation	percent	49.11	47.27	48.33	56.41	57.63
20. Mole fraction of dry gas	Fmd	0.5089	0.5273	0.5167	0.4359	0.4237
21. Gas analysis						
Average CO ₂ by volume	percent	9.38	9.00	9.20	7.60	8.00
Average O ₂ by volume	percent	6.13	5.47	4.50	6.60	5.90
Average C ₆ by volume	percent	0.00	0.00	0.00	0.00	0.00
Average N ₂ by volume	percent	84.50	85.53	86.30	85.80	86.10
22. Dry molecular weight of stack gas	lb/lb-mol	29.75	29.66	29.65	29.48	29.52

Table 9. (continued)

Parameter	Units	Test Burn ^a				
		(12-6)	(12-7)	(12-15)	(12-15)	(12-15)
23. Molecular weight at stack conditions	lb/lb-mol	23.75	24.15	24.04	23.00	22.88
24. Average stack temperature	°R	644	646.8	644	648.6	648.5
25. Average stack gas velocity	ft/sec	56.59	61.24	60.70	68.70	83.49
26. Stack area	sq-in	706.9	706.9	706.9	706.9	706.9
27. Actual stack gas flowrate	scfh	999.981	1082.259	1072.648	1214.117	1475.353
28. Dry stack gas flowrate (standard)	scfh	424.753	472.661	460.749	437.146	515.261
30. Weight of filterable particulates	mg	24.1	40.8	35.4	41.2	44.1
31. Particulate concentration (at standard conditions)	lb/dscf mg/dscf gr/dscf mg/dscm	1.07E-09 0.48 0.007 17.065	2.67EE-09 1.21 0.019 42.694	2.29E-09 1.04 0.016 36.612	2.98E-09 1.35 0.021 47.773	2.69E-09 1.22 0.019 43.010
32. Particulate concentration (corrected to 6 percent oxygen)	lb/dscf mg/dscf gr/dscf mg/dscm	1.07E-09 0.49 0.000 17.210	2.57E-09 1.17 0.018 41.219	2.08E-09 0.94 0.015 33.264	3.11E-09 1.41 0.022 49.778	2.67E-09 1.21 0.019 42.724
29. Isokinetic rate	percent	75.6	103.8	107.7	101.0	101.7
33. Particulate concentration (corrected to 12 percent carbon dioxide)	lb/dscf mg/dscf gr/dscf mg/dscm	1.36E-09 0.62 0.010 21.844	3.41E-09 1.55 0.024 54.649	2.93E-09 1.33 0.020 46.864	3.82E-09 1.73 0.27 61.150	3.44E-09 1.56 0.024 55.053
34. Pollutant mass rate	lb/hr g/hr gr/hr	4.53E-04 205.3 3168	1.26E-03 571.5 8818	1.05E-03 477.7 7372	1.30E-03 591.4 9126	1.38E-03 627.6 9684

a. Sample collection data for Test 4 on December 8, 1986, are not included because samples were not analyzed. Detailed field test data sheets are provided in Appendix P.

Figure 41. View of sampling head for PUF ambient air sampler.



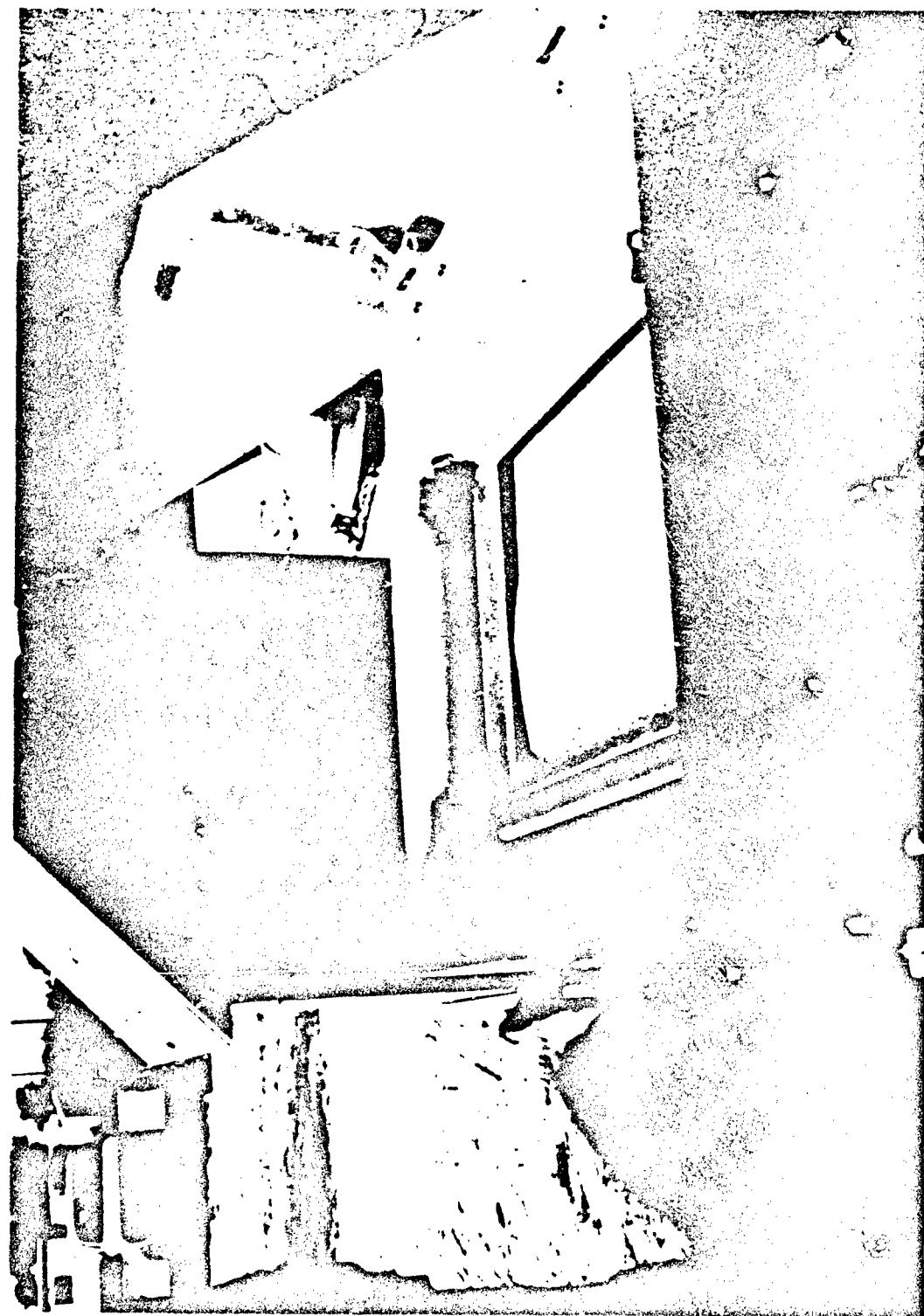
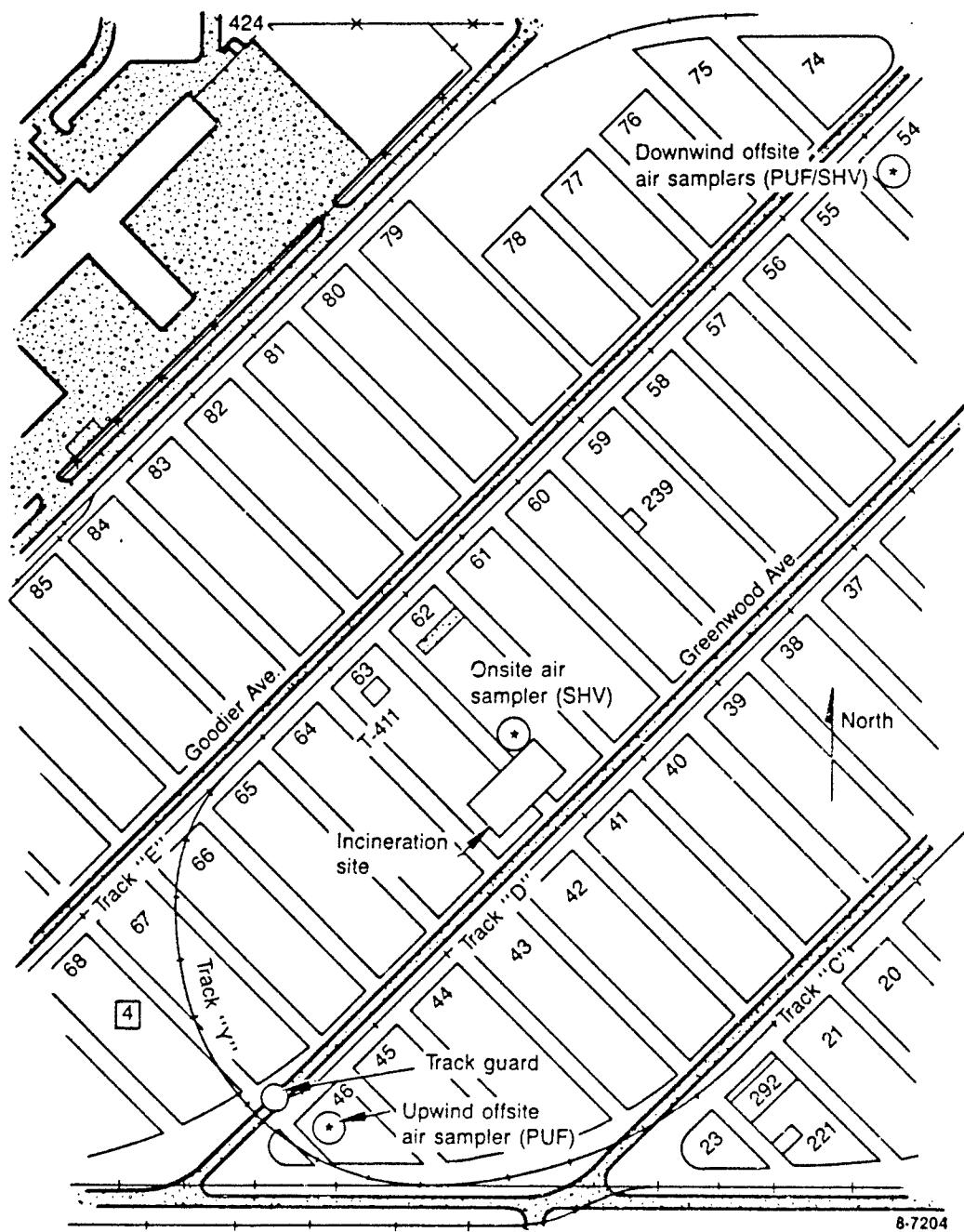


Figure 42. View of sampling head for standard high volume ambient air sampler.

To determine any impact from the activities, three air sampler locations were established to provide control and exposure data. Figure 43 shows the placement of air samplers as configured during soil incineration. Placement was based on a wind flow from the southeast. Therefore, the offsite upwind (control), onsite downwind (local exposure), and offsite downwind (exposure) air samplers were placed on a 130-degree line (relative to the wind dose) which crosses the activity that was being monitored. A PUF sampler was used exclusively for the upwind control monitoring. Both PUF and SHV samplers were used for the local and offsite downwind monitoring. In Figure 43, the activity being monitored was incineration; the same logic applied to excavation activities as well. At least every 2 hours the wind direction was checked, and if it was ± 30 degrees away from the present air sampling placement, the location of the samplers was changed so they were along the same direction as the wind relative to the monitored activity. Figure 44 shows a view of the two samplers as they were positioned at the onsite location.

Prior to use, all samplers were calibrated at the NCBC site, using a variable-resistance calibration orifice and National Bureau of Standards reference. The volume of air passing through each of the sampler filters was calculated by correcting the calibrated flow rate with the average temperature and barometric pressure encountered during the sample period. The average temperature and pressure were determined from hourly onsite readings.

Eight PUF filter samples and 13 SHV filter samples were collected over the 12-day span. These samples are listed in Table 10 in a chronological order with sampling time and air flow data included. During changeout of sample filters, each filter holder was left in its holder and placed in a plastic seal bag. These samples were packed in the coolers with the material and gas samples previously discussed for shipment to ITAS.



8-7204

Figure 43. Placement of ambient air samplers at NCBC site.

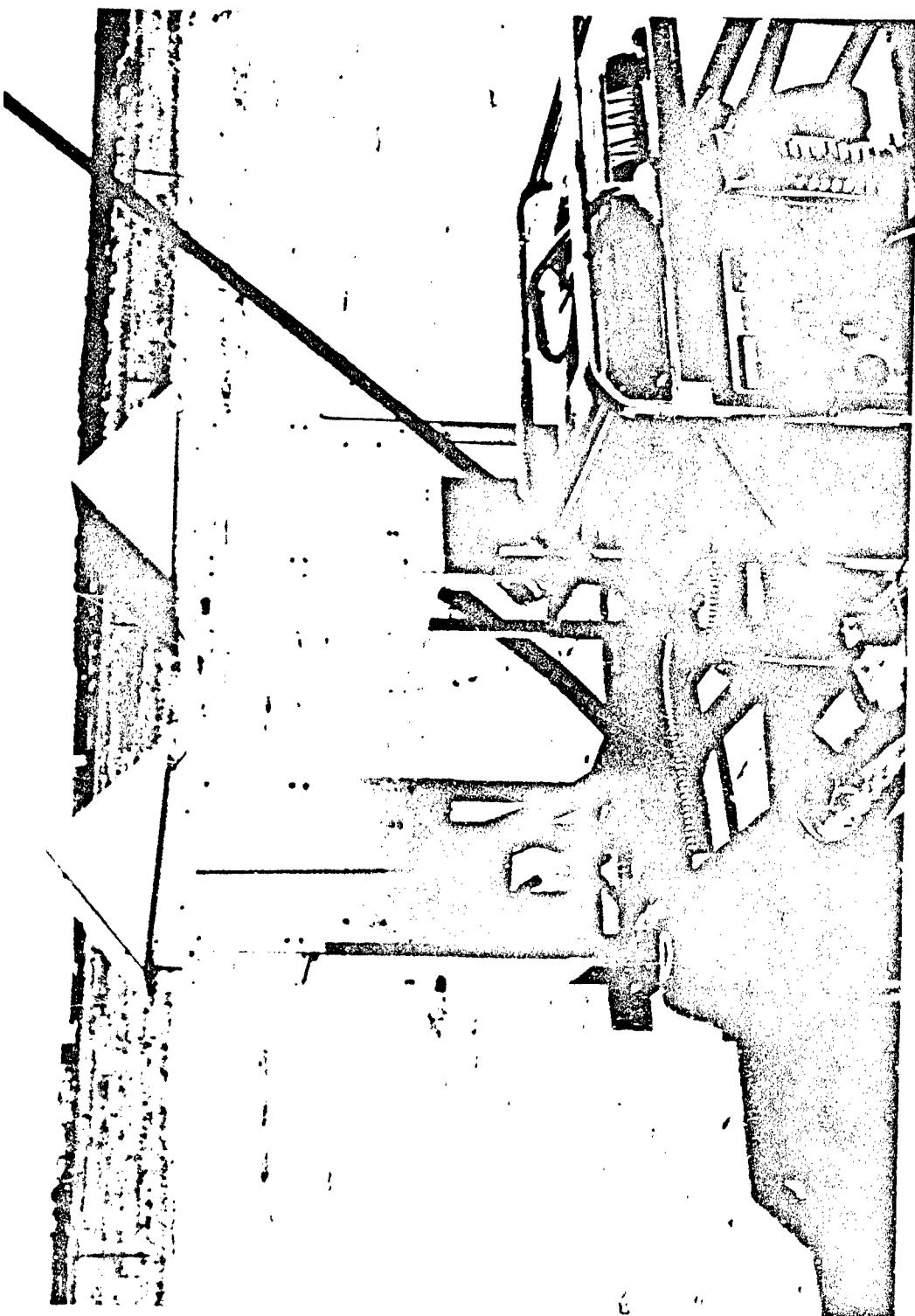


Figure 44. View of side-by-side samplers for onsite ambient air monitoring.

Table 10. Summary of ambient air sampling and particulate concentrations

<u>Date^a</u>	<u>Filter Number</u>	<u>Location</u>	<u>Sampling Time (hr)</u>	<u>Volume of Air Sampled (m³)</u>	<u>Particulate Weight (mg)</u>	<u>Particulate Concentration (μg/m³)</u>
12-4	P-3	Upwind	8.3	134	12.6	95
12-4	P-5	Onsite	8.0	129	9.7	74
12-4	H-8	Onsite	8.0	653	29.3	46
12-4	P-4	Downwind	8.1	131	10.2	78
12-4	H-9	Downwind	8.1	661	18.4	28
12-5,6, 7,8,15	P-1	Upwind	44.2	714	54.2	78
12-5,6, 7,8,15	P-6	Downwind	40.7	657	57.9	88
12-5	H-7	Onsite	9.1	742	23.6	35
12-5	H-6	Downwind	8.6	702	16.3	23
12-6	H-3	Onsite	6.6 ^c	538	45.8	85
12-6	H-4	Onsite	2.3 ^d	188	0.0	0
12-6	H-5	Downwind	8.4	685	22.5	33
12-7	H-1	Onsite	8.2	669	73.4	109
12-7	H-2	Downwind	11.0	897	66.8	74
12-8	H-12	Onsite	9.5	775	33.4	42
12-8	H-11	Downwind	9.5	775	52.5	67
12-11,12	P-20	Onsite	24.5	396	8.5	22
12-12,13, 14	P-22	Onsite	64.8	1046	25.5	24
12-15	P-745	Onsite	24.4	394	7.7	19
12-15	H-10	Onsite	7.5	612	40.8	67
12-15	H-13	Downwind	7.5	612	25.7	42

a. See text for primary activity during sampling.

b. Nominal air flow rates: SHV, 1.36 m³/min (48 cfm); PUF, 0.27 m³/min (9.5 cfm).

c. Sampled during test burn.

d. Sampled during soil excavation.

The particulate concentrations for each filter sample are also listed in Table 10. The data for December 14 show two interesting trends. During the soil excavation activities, the downwind locations actually showed lower concentrations compared to the upwind control. Also, in side-by-side comparisons, the SHV filter concentrations were consistently and substantially lower than the PUF filter concentrations. Such a bias presents difficulty in comparing results between PUF and SHV filter samples.

Comparison of the PUF upwind control and downwind offsite samples (P-1, P-6) during the test burns showed only a minor increase in the downwind locations ($78 \mu\text{g}/\text{m}^3$ upwind, $88 \mu\text{g}/\text{m}^3$ downwind). Both readings are well within the threshold limit value (TLV) of $10 \text{ mg}/\text{m}^3$ for total dust exposure on an occupational basis (Reference 25). With one exception, the remaining SHV filter data show slightly higher onsite particulate exposures than downwind for coincident sampling periods. The highest particulate loading occurred onsite (sample H-1) during December 7 at a concentration of $109 \mu\text{g}/\text{m}^3$, which is well below the TLV.

Two PUF samples (P-20 and P-745) and two SHV samples (H-11 and H-13) were also analyzed for HO constituents, 2,4-D and 2,4,5-T. These results are presented in Section V.C.3.

SECTION V

SAMPLE ANALYSIS

Table 11 presents the analytical matrix for the process samples analyzed from the verification test burns. The matrix consists of dioxins/furans, organics, inorganics, chlorides, and particulates. Test samples are from soil feedstock, treated soil (ash drag), effluent neutralization tank liquid, other system water sampling, MM5 and VOST stack gas sampling, and ambient air sampling. Blank, duplicate, and spike samples are noted in the listing. Some samples such as the kiln treated soil and quench/scrubber fines were not analyzed as part of the verification program, but archive samples were retained. This section presents: (a) ITAS methods/protocols, (b) data validation review, and (c) data results.

A. METHODS/PROTOCOLS

IT Analytical Services of Knoxville, Tennessee, performed the analyses. The samples were received in three shipments: December 9, 17, and 18, 1986. The total samples received included 11 soil samples, 12 water samples, 5 MM5 stack samples plus associated blanks, 16 VOST pairs, and 10 air filters.

The methods and protocols were drawn from the EPA CLP procedures and are summarily listed in Table 12. A brief discussion of these methods and protocols as followed is presented below. Detailed narratives taken from the analytical reports (References 29, 30) are included within Appendices T and U.

1. Dioxins/Furans

a. Sample Preparation and Cleanup

As shown in the sample analysis matrix (Table 11), soil, water, and stack gas samples were submitted for the analysis of both

Table 11. Verification sample analysis matrix performed for incineration test burns at NCBC

Sample ^a	Analytical Category				
	Dioxins/Furans ^b	Organics ^c	Inorganics ^d	Chlorides	Particulates
<u>Feedstock</u>					
FS-1	x	x	x	--	--
FS-2	x	x	x	--	--
FS-3	x	x	x	--	--
FS-5	x	x	x	--	--
FS-6	x	x	x	--	--
<u>Treated Soil (ash drag)^e</u>					
AD-1	x	x	x	--	--
AD-2	x	x	x	--	--
AD-3	x ^f	x	x	--	--
AD-5	x ^f	x	x	--	--
AD-6	x	x	x	--	--
BS-1 ^g	x	x	x	--	--
<u>Effluent Neutralization Tank</u>					
ENT-1	x ^f	x	--	--	--
ENT-2	x ^f	x	--	--	--
ENT-3 ^h	--	--	--	--	--
ENT-5	x	x	--	--	--
ENT-6	x	x	--	--	--
ENT-b(blank) ⁱ	x	x	--	--	--
<u>Boiler Water Blowdown</u>					
BB-1 ^j	--	--	x	--	--
BB-2 ^k	--	--	--	--	--
BB-3 ^k	--	--	--	--	--
BB-5	--	--	x	--	--
BB-6	--	--	x	--	--
<u>Water Supply</u>					
CW ^l	x ^f	x	--	--	--
WB-1 ^m	x ^f	x	--	--	--
<u>Liquid to POTW</u>					
POTW ⁿ	x	x	x	--	--

Table II. (continued)

<u>Sample^a</u>	<u>Analytical Category</u>				
	<u>Dioxins/Furans^b</u>	<u>Organics^c</u>	<u>Inorganics^d</u>	<u>Chlorides</u>	<u>Particulates</u>
<u>Stack Gas (MM5 composites)</u>					
VB-1	x	x	--	x	x
VB-2	x	x	--	x	x
VB-3	x	x	--	x	x
VB-5	x	x	--	x	x
VB-6	x	x	--	x	x
XAD blank	x	x	--	x	x
<u>Stack Gas (VOST)</u>					
VOST-1	--	x ⁰	--	--	--
VOST-2	--	x ⁰	--	--	--
VOST-3	--	x ⁰	--	--	--
VOST-5	--	x ⁰	--	--	--
VOST-6	--	x ⁰	--	--	--
VOST-blank	--	x ⁰	--	--	--
<u>Ambient Filter Samples</u>					
14820	--	x ^p	--	--	x
14821	--	x ^p	--	--	x
14822	--	x ^p	--	--	x
14749	--	x ^p	--	--	x
17962	--	x ^p	--	--	x
17963	--	x ^p	--	--	x
17964	--	x ^p	--	--	x
17966	--	x ^p	--	--	x
17967	--	x ^p	--	--	x
17968	--	x ^p	--	--	x

a. Kiln soil samples taken were not included in the verification analysis. Samples from each test were sent to Region IV, ENSCO, ITAS, and archive. Also, the quench/scrubber fines samples were not analyzed but kept for archive.

b. Except where noted, includes 2,3,7,8-TCDD, 2,3,7,8-TCDF, and total PCDD/PCDF.

c. Except where noted, includes acid-type semivolatiles (16), polynuclear aromatic hydrocarbons (7), other base/neutral-type semivolatiles (8), organochlorine pesticides (1), PCBs (7), and herbicides (2).

TABLE 11. (continued)

- d. Represents 9 metals.
- e. Each sample was also analyzed for cyanide and sulfide.
- f. Includes duplicate and spike samples.
- g. Background soil sample.
- h. Sample was not analyzed, kept for archive.
- i. Blank sample.
- j. Sample was also analyzed for BOD and COD.
- k. Sample was not analyzed, kept for archive.
- l. Caustic water sample.
- m. Background water sample obtained from tap water used for feed water to incinerator operations.
- n. Sample represents created ENT water in POTW holding tank after all tests before discharging from site to POTW.
- o. Analyzed for 16 volatile organics.
- p. Analyzed for only herbicides (2,4-D and 2,4,5-T).

Table 12. Summary of analytical methods used for samples from incineration verification test burns at NCRC

Analyte	Matrix	Method	Description
PCDD/PCDF (total)	Water	ITAS S0P ^a	U.S. EPA CLP ^b plus Method 8280C modified for HRGC/HRMS
	Soil	ITAS S0P ^a	U.S. EPA CLP ^b plus Method 8280C modified for HRGC/HRMS
	Stack gas	ITAS S0P ^a	U.S. EPA CLP ^b plus Method 8280C modified for HRGC/HRMS
Extractable organics (acid and base/ neutral)	Water	ITAS S0P ^a	U.S. EPA CLP plus Method 8280 ^c modified for HRGC/HRMS
	Soil	ITAS S0P ^a	U.S. EPA CLP plus Method 8280C modified for HRGC/HRMS
	Stack gas	ITAS S0P ^a	U.S. EPA CLP plus Method 8280C modified for HRGC/HRMS
PAHs	Water	U.S. EPA CLP S0W ^d	L/L extraction, GC/MS analysis
	Soil	U.S. EPA CLP S0W ^d	Sonification extraction, GC/MS analysis
	Stack gas	Methods 3510, 3540, ^c U.S. EPA CLP S0W ^d	L/L and Soxhlet extraction, combine extracts and analyze per CLP
Toxaphene/PCBs	Water	Method 8310C	L/L extraction, HPLC analysis
	Soil	Methods 3540, 3550	Soxhlet or sonification extraction, HPLC analysis
	Stack gas	Methods 3510, 3540 and 8310C	L/L and Soxhlet extraction, combine extracts, HPLC analysis
Herbicides	Water	U.S. EPA CLP S0W ^d	L/L extraction, GC/MS analysis
	Soil	U.S. EPA CLP S0W ^d	Sonification extraction, GC/MS analysis
	Stack gas	Methods 3510, 3540, ^c U.S. EPA CLP S0W ^d	L/L and Soxhlet extraction, combine extracts and analyze per CLP
Metals	Water	Method 8150C	Extraction, methylation, GC/EC
	Soil	Method 8150	Extraction, methylation, GC/EC
	Stack gas	Methods 3510, 3540, and 8150C	L/L and Soxhlet extraction, combine and methylate extracts, GC/IC
PCPs	Water	U.S. EPA CLP S0W ^e	Digestion, AA or GFAA analysis
	Soil	U.S. EPA CLP S0W ^e	Digestion, AA or GFAA analysis
	VOST HMS	Method 3720 Methods 3510, 3540, ^c and U.S. EPA CLP S0W ^d	Thermal desorption, GC/MS L/L and Soxhlet extraction, combine extracts and analyze per CLP

a. See Appendix Q for ITAS SOPs.

b. See Appendix R for U.S. EPA CLP required detection limits.

c. Methods from EPA SW-846 (Reference 19).

d. Statement of Work, "Organic Analysis, Multi-Media, Multi-Concentration," July 1985 Revision.

e. Statement of Work, "Inorganic Analysis, Multi-Media, Multi-Concentration," SOW No. 785, July 1985.

isomer-specific 2,3,7,8-TCDD/TCDF and total dioxin and total dibenzofuran congeners from Cl₄ through Cl₆ (tetra, penta, hexa).^a The samples and a blank were spiked with the following internal standard/surrogate mixtures depending on the resolution of MS analysis:

<u>Resolution MS</u>	<u>Compound</u>	<u>Quantity (ng)</u>
Low ^b	2,3,7,8-TCDD- ¹³ C ₁₂	50
	2,3,7,8-TCDD- ³⁷ C ₁₄	10
	P ₅ CDD- ¹³ C ₁₂	50
	P ₅ CDF- ¹³ C ₁₂	50
High ^c	2,3,7,8-TCDD- ¹³ C ₁₂	50
	2,3,7,8-TCDD- ³⁷ C ₁₂	50
	P ₅ CDD- ¹³ C ₁₂	50
	H _x CDD- ¹³ C ₁₂	50
	TCDF- ¹³ C ₁₂	50
	P ₅ CDF- ¹³ C ₁₂	50
	H _x CDF- ¹³ C ₁₂	50

a. These congeners are consistent with the AFESC goal stated in Section I.A. The analytical laboratory procedures included PCDD/PCDF congeners from Cl₇ and Cl₈ (hepta, octa). Although not reported in the text of Volume I, hepta and octa data are shown in the ITAS data sheets (Appendix S).

b. H_pCDD-¹³C₁₂ and OCDD-¹³C₁₂ in 50 ng quantities each were also used to spike the samples for the hepta and octa analyses.

c. H_pCDD-¹³C₁₂, OCDD-¹³C₁₂, and H_pCDF-¹³C₁₂ in 50 ng quantities each were also used to spike the samples for the hepta and octa analyses.

The samples were extracted and cleaned up, using modifications of the EPA reference method described in Method 8280, "Analysis for Chlorinated Dibenzo-p-dioxins and Dibenzofurans," revised September 1986 (Reference 31). Separate method modifications of the basic procedure were used for a diverse set of samples: soil, water, XAD tubes/ambient air filters, and MM5-condensate/water impingers/probe rinse. The extracts from the MM5-condensate/water impingers/probe rinse were combined with the corresponding XAD extracts. To aid in the removal of chemical interferences, the samples and blank were cleaned up using dual-column chromatography consisting of an acid-modified silica gel column followed by a neutral alumina column.

b. Isomer-Specific Analysis

Because of the concentration levels of 2,3,7,8-TCDD in the feedstock samples, the extracts for these samples were analyzed for isomer-specific TCDD/TCDF using HRGC/LRMS with scanning in the selected ion monitoring mode. The extracts for the other samples were analyzed using HRGC/HRMS because of expected very low or undetectable concentrations. The same scanning mode was used. For both detection levels, a 60-meter SP 2331 fused-silica column was used for the isomer-specific analysis.

Before acquisition of the samples, a seven isomer performance mixture containing the six most closely eluting TCDD isomers was run. In addition, a five-point calibration plot was run in triplicate. The mean response factors obtained from the 15-point calibrations were used for all subsequent calculations. The shift standard, analyzed on the same day before the samples, produced a response factor within 10 percent of the 15-point calibration. For isomer-specific analysis, the detection limit was calculated from 2.5 times the signal in the area of the elution of 2,3,7,8-TCDD-¹³C₁₂ (or 2,3,7,8-TCDF-¹³C₁₂) whenever the sample contained no detectable 2,3,7,8-TCDD (or 2,3,7,8-TCDF).

c. Total Dioxin/Furan Analysis

A with the isomer-specific analysis, the extracts of the feedstock samples were analyzed for total dioxins and furans using HRGC/LRMS with scanning in the selected ion monitoring mode for enhanced sensitivity. HRGC/HRMS was used for the other samples. A 30-meter DB-5 fused-silica column was used for both levels of concentration analyses.

The analytical approach used by ITAS for the determination of total dioxins and furans is considered semiquantitative because of the lack of availability of all dioxin and furan isomer standards. A standard was injected at the beginning of each day to calculate response factors. The response factor solution contained the following isomer standards:

Dioxins ^a	Furans ^b
2,3,7,8-TCDD	2,3,7,8-TCDF
1,2,3,4-TCDD	--
1,2,3,7,8-P ₅ CDD	1,2,3,7,8-P ₅ CDF
1,2,3,4,7,8-H _x CDD	1,2,3,4,7,8-H _x CDF
2,3,7,8-TCDD- ¹³ C ₁₂	2,3,7,8-TCDF- ¹³ C ₁₂
2,3,7,8-TCDD- ³⁷ C ₁₄	--
1,2,3,7,8-P ₅ CDD- ¹³ C ₁₂	--
1,2,3,7,8-P ₅ CDF- ¹³ C ₁₂	--

a. Also included 1,2,3,4,6,7,8-H_pCDD, OCDD, and OCDD-¹³C₁₂.

b. Also included 1,2,3,4,6,7,8-H_pCDF and OCDF.

Response factors were calculated for each compound in the standard with relation to TCDD- $^{13}\text{C}_{12}$; the same response was assumed applicable to all isomers in each congener group. A three-point calibration plot was run in triplicate. The mean response factors obtained from the nine-point calibration were used for all subsequent calculations. The shift standard analyzed on the same day as the samples produced a response factor within 30 percent of the multipoint. For the HRGC/LRMS analyses, TCDD- $^{37}\text{Cl}_4$, P₅CDD- $^{13}\text{C}_{12}$, H_pCDD- $^{13}\text{C}_{12}$, OCDD- $^{13}\text{C}_{12}$, and P₅CDF- $^{13}\text{C}_{12}$ were used to calculate the accuracy of recovery efficiencies. Whereas for the HRGC/HRMS analyses, TCDD- $^{37}\text{Cl}_4$ was used.

To achieve adequate sensitivity, the samples were analyzed twice each: the first time for dioxins and the second time for furans. For total congener analysis, the detection limit was calculated from 2.5 times the signal-to-noise ratio. Duplicate and spiked samples were analyzed for each of the following sample types: soil (AD-5) and liquid (ENT-2, WB-1). Analysis blanks were also performed as part of the quality assurance.

2. Volatile Organics

The VOST samples were analyzed for products of incomplete combustion (PICs) following EPA Method 3720 (Reference 26). The Tenax^R and Tenax^R/charcoal VOST tubes were spiked with internal standards and surrogates, then thermally desorbed directly into the purging tube of the purge-and-trap device for analysis. The samples were analyzed by purge-and-trap GC/MS in accordance with the EPA CLP Statement of Work (SOW), July 1985 revision. The column used for this analysis was a 6-foot by 4 mm inside diameter glass column packed with 1 percent SP-1000 on 60/80 mesh Carbopack B.^R The column was interfaced to the ion source by a glass jet separator. Before sample analysis, the system was tuned to EPA criteria. Tuning was checked every 12-hour shift. An initial five-point calibration was run.

The following problems were encountered during the analysis. The VOST tube sample pairs for Test 3 (Sample pairs: 14799 and 14805, 14800 and 14803) were lost due to instrument failure. Instrument instability required recalibration and delayed the analysis of VOST-1-C, -2-C, and -3-C of Tests 1, 2, and 3 until 6 days past the allowed 14-day period after receipt. However, the results (discussed in Section V.C) are similar to those for VOST-5-C and -6-C of Tests 5 and 6, which were analyzed within this allowed holding time.

3. Polynuclear Aromatic Hydrocarbons

Soil, water, and stack gas samples were analyzed for polynuclear aromatic hydrocarbons (PAHs). The low concentration water samples of 1-liter quantity were triple extracted with methylene chloride, filtered, and concentrated for analysis. The soil samples (10 grams) were extracted with methylene chloride in a Soxhlet^R extractor for 24 hours, filtered, and concentrated to 1 mL. The extract was solvent exchanged into acetonitrile and reconcentrated in 1 mL for analysis.

All sample extracts were analyzed by high-performance liquid chromatography (HPLC) in accordance with EPA Method 8310 (Reference 26). The column used in this analysis was a Supelco LC-PAH 25 cm by 4.6 mm insider diameter column plus a LC-18 guard column 2 cm by 4.6 mm (5 μ m film thickness). The liquid chromatograph was equipped with a variable wavelength ultraviolet absorbance detector and a fluorescence spectrophotometric detector. The HPLC was initially calibrated using a three-point standard curve. Linearity was checked at the beginning of each day. A check standard and a check solvent blank were alternated after every five samples. Column calibration was performed by running a 3-point calibration for each compound.

The following problems were encountered during the analysis of the feedstock samples. Samples for FS-1 and FS-2 (and their QC samples) were filtered using an 0.45- μ m syringe filter before injection onto the HPLC column. Due to the matrix of the samples, they were prepped and

concentrated to approximately 5 mL in acetone. They were then brought to a 10-mL volume using HPLC grade acetonitrile. The FS-2 sample (and the two QC samples) could be injected on the column at no lower a volume than 1 to 10 mL. This, plus the initial high volume of extract, multiplied the detection limit by a factor of 100.

In the other problem, the samples for FS-5 and FS-6 could be injected at no lower a dilution than 1 to 100 because of matrix problems. The samples contained an impurity that adhered to the HPLC column and required prolonged organic solvent flushes to remove it, although even after subsequent removal and reconditioning, column efficiency was diminished. This high dilution combined with the larger extract volume (10 mL) raised the detection limit by a factor of 1000.

4. Extractable Organics (Acids and Base/Neutrals)

Soil, water, and stack gas samples were analyzed for extractable semivolatile organic compounds (acid and base/neutral types). The low concentration water samples of 1-liter quantity were pH adjusted ($\text{pH} > 11$) with 10 N sodium hydroxide and triple extracted with methylene chloride. The extracts were then combined to represent the base/neutral fraction. The water sample was again adjusted for pH (< 2) using sulfuric acid and triple extracted with methylene chloride with the extracts then combined to represent the acid fraction. The resulting extracts were filtered and concentrated to a volume of 1 mL for analysis.

The low concentration soil samples of 30 grams quantity were mixed with 30 grams of anhydrous sodium sulfate. The samples were spiked with surrogate standards and triple extracted with methylene chloride using an ultrasonic probe. The extracts were filtered, combined, and concentrated to a volume of 10 mL. The extract was split into two fractions. One fraction (9.5 mL) was concentrated to a volume of 0.95 mL for GC/MS analysis of acids and base/neutrals. The other fraction (0.5 mL) was solvent exchanged into hexane, cleaned up using a micro alumina column, brought to a volume of 1 mL, and analyzed by GC/MS for pesticides and PCBs.

Medium concentration soil samples of 1-gram quantity were mixed with 2 grams of anhydrous sodium sulfate. The samples were then spiked with surrogate standards and extracted with methylene chloride using an ultrasonic probe. The extracts were filtered and concentrated to a volume of 1 mL.

The sample extracts were analyzed by fused silica capillary column (FSCC)--GC/MS procedures in accordance with the EPA CLP Statement of Work, July 1985 revision. The column used for the analysis was a 30-meter DB-5 fused silica capillary column with a 0.32 mm inside diameter and 1.0 μ m film thickness. The column was connected directly to the ion source. Prior to sample analysis, the system was tuned to meet EPA criteria for a 50 ng injection of decafluorotriphenylphosphine (DFTPP). The tuning was checked every 12 hour shift. An initial five-point calibration was run and the mean response factor and percent relative standard deviation were calculated for each compound.

Water samples ENT-5, ENT-6, POTW, CW, WB-1, along with WB-1 matrix spikes, were analyzed and found to have low acid surrogate recoveries. These samples were reextracted and reanalyzed with acceptable surrogate results. The reextraction was outside the usual sample holding time.

5. Organochlorine Pesticides and PCBs

Soil, water, and stack gas samples were analyzed for toxaphene and seven PCBs. The low concentration water samples of 1-liter quantity were spiked with the surrogate solution and triple extracted with methylene chloride. The resulting extracts were filtered through conditioned sodium sulfate and concentrated to a volume of 1 mL. The extract was cleaned up using a micro alumina column, solvent exchanged into hexane, and concentrated back to 1 mL.

The extraction process for the low-concentration soil samples was combined with that for the extractable organic samples (see Section V.A.4).

The medium concentration soil samples of 1-gram quantity were mixed with 2 grams of anhydrous sodium sulfate. The samples were then spiked with surrogate standard and extracted with hexane using an ultrasonic probe. The extracts were filtered and concentrated to 0.5 mL. Acetone was added and the extracts were cleaned up using a micro alumina column, solvent exchanged into hexane, and concentrated to a volume of 1 mL.

The sample extracts were analyzed for organochlorine pesticides and PCBs by packed column GC using an electron capture detector (ECD) in accordance with the EPA CLP Statement of Work, July 1985 revision. The columns used for this analysis were a 6 foot by 4 mm inside diameter glass column packed with 1.5 percent SP-2250/1.95 percent SP-2401 on 100/200 mesh Supelcoport. The gas chromatograph was equipped with a Ni-63 electron capture detector. Linearity was checked at the beginning of each 72-hour analytical sequence. If the column was being used for quantitation, all linearity requirements were met before analysis of sample extracts. Calibration standards of all compounds to be identified, quantitated, and/or confirmed were analyzed after the linearity standards. Degradation was checked by calculating the percent breakdown of Endrin/4,4'-DDT. Degradation did not exceed 20 percent for Endrin or 4,4'-DDT. A calibration check standard and degradation check standard were alternately run after every five samples and at the end of the analytical sequence.

6. Herbicides

Soil, water, stack gas, and ambient filter samples were analyzed for the herbicides 2,4-D and 2,4,5-T. The water samples of 1-liter quantity were acidified with HCl to a pH of 2 and triple extracted with diethyl ether. The extracts were hydrolyzed with potassium hydroxide and extraneous organic material was removed with a solvent wash. The extract was then concentrated and methylated for analysis.

The soil samples of 50 grams quantity were acidified with HCl to a pH of 2 and triple extracted with a 1:4 mixture of acetone/diethyl ether. The extract was then concentrated and methylated for analysis.

The sample extracts were analyzed by GC/ECD in accordance with EPA Method 8150 (Reference 26). The column and GC used were the same as described for the pesticide/PCB analysis (see Section V.A.5). The GC was initially calibrated in replicate using a three-point standard curve. The calibration curve was checked daily by the analysis of one or more calibration standards.

7. Inorganics

a. Metals

Soil, water, and stack gas samples were analyzed for nine metals. For water samples being prepared for digestion prior to furnace analysis, 1 mL of (1:1) HNO₃ and 2 mL of 30 percent H₂O₂ were added to 100 mL of each sample. The sample mixtures were heated for 2 hours at 95°C or until the volumes were reduced to between 25 and 50 mL. The samples were cooled and brought back to a 100 mL volume with distilled deionized water. For water samples being prepared for digestion prior to analysis by inductively coupled argon plasma (ICP)/flame atomic absorption (AA), the extraction procedure was the same except that 2 mL of (1:1) HNO₃ and 10 mL of (1:1) HCl were added to 100 mL of each sample.

The soil samples of 1-gram quantity were refluxed for 10 minutes with 10 mL of (1:1) HNO₃. Five mL of concentrated HNO₃ was added and each sample was refluxed for an additional 30 minutes. After cooling, 2 mL of water and 3 to 10 mL of 30 percent H₂O₂ were added, and the samples were warmed until the reaction was complete. For ICP analyses, 5 mL of (1:1) HCl and 10 mL of water were added to the samples and the mixtures were refluxed for an additional 10 minutes. For furnace AA analyses, the samples were reduced to 2 mL, 10 mL of water was added, and the mixture was heated. These samples were then cooled, filtered, and diluted to 200 mL.

The sample extracts were analyzed for metals on the PPL and total cyanide in accordance with the EPA CLP Statement of Work, July 1985

revision. This protocol provides for the determination of metals by inductively coupled argon plasma (ICP), graphite furnace atomic absorption (GFAA), and cold vapor (CV) atomic absorption technique for mercury. Alternatively, flame atomic absorption methods (AA) may be substituted for ICP. Calibration requires the preparation of a standard curve, one standard of which was at the contract required detection limit, except for mercury. For AA analysis, no fewer than three nonzero standards were used to generate the curve. For GFAA and CV, each standard was analyzed at least three times. Standard reference material, used as initial calibration verification standards, was used to verify that the standard curve had been developed accurately. Calibration for ICP uses one non-zero standard for each element, plus the calibration blank. A standard designed to monitor potential interferences was analyzed as part of the verification process. For GFAAS, AA, and CV, the samples were analyzed in duplicate. The standard addition method was used for GFAA. The continuing calibration verification standard was analyzed after every fifth sample and was preceded by a calibration blank analysis.

The following problems were encountered during the analysis. The metals normally analyzed by ICP were analyzed by AA due to a malfunctioning ICP unit. Lead was detected in preparation blanks for liquid and solid samples at a concentration less than the contract required detection limit ($2.4 \mu\text{g/L}$) and close to the instrument detection limit ($1.2 \mu\text{g/L}$). The following elements were labeled as being in nonconformance regarding duplicate preparation: Hg in sample ENT-5, Hg and Pb in sample FS-1. These same two samples were also labeled being in nonconformance for spike recovery: Pb, Hg, and Se for sample ENT-5, as for sample FS-1. As commented by ITAS, low recovery for the single standard addition method were observed during the mercury analysis for the ENT-5 spike. A spike of 0.004 ppm mercury was added because the normal spike of 0.001 ppm could not be seen.

b. Cyanide

Soil samples were analyzed for cyanide in accordance with the EPA CLP Statement of Work, July 1985 revision. Cyanide as HCN was released from cyanide complexes in the samples by means of a reflux-distillation procedure and absorbed in a scrubber containing sodium hydroxide solution. The cyanide ion in the absorbing solution was then determined colorimetrically.

c. Chloride

The samples were analyzed for chloride by EPA Method 325.3 (Titrimetric, Mercuric Nitrate) (Reference 28). The acidified sample was titrated with mercuric nitrate in the presence of mixed diphenylcarbazone-bromophenol blue indicator. The end point of the titration is the formation of the blue-violet mercury diphenylcarbazone complex.

d. Sulfides

Soil samples were analyzed in accordance with EPA Method 9030 (Reference 26). A 1-2 gram portion of the sample was diluted with 200 mL of distilled deionized water. Excess iodine was added to the sample and back-titrated with sodium thiosulfate.

8. Other

a. Biochemical Oxygen Demand

The samples were analyzed for biochemical oxygen demand (BOD) in accordance with EPA Method 405.1 (Reference 21). The original sample and serial dilutions were incubated for 5 days at 20°C in the dark. The dissolved oxygen concentration was measured at the beginning and end of the incubation period. The reduction in dissolved oxygen yields a measure of the BOD.

b. Chemical Oxygen Demand

The samples were analyzed for chemical oxygen demand (COD) in accordance with EPA Method 410.2 (Reference 28). The organic and oxidizable substances in the sample were oxidized by potassium dichromate solution in 50 percent (by volume) sulfuric acid solution. The excess dichromate was titrated with standard ferrous ammonium sulfate using the ferrous orthophenanthroline complex (ferroin) as an indicator.

c. pH

The pH of the samples was determined electrometrically in accordance with EPA Method 150.1 (Reference 26). Water samples were measured directly with a glass pH electrode. Soil samples were mixed 1:1 with distilled deionized water, stirred for 1 hour, and measured with a glass pH electrode.

B. INDEPENDENT REVIEW/EVALUATION

The ITAS data packages for the dioxin/furan analysis (Reference 29) and organic/inorganic analysis (Reference 30) have been reviewed by the Chemical Sciences Group at EG&G Idaho. The narrative and significant data sheets for each data package are included as exhibits in Appendices T and U, respectively. Table 11 presents the matrix of samples for which data was reviewed. Table 12 presents a summary of analytical methods used and briefly discussed in Section V.A. This section summarizes the results of the EG&G Idaho review. This review consists of the following parts: general comments, dioxins/furans, volatile organics, PAHs, extractable organics (bases/ neutrals/ acids), pesticides and PCBs, herbicides, and inorganics. Conclusions on the acceptability of the data follow at the end. A detailed report is presented in Appendix U.

1. General Comments

Samples were received by ITAS in three separate shipments on December 9, 17, and 18, 1986. EG&G Idaho, Inc., Chemical Sciences personnel were present at the laboratory when the last two shipments were received, providing laboratory oversight and an interface between sampling operations in the field and the laboratory.

ITAS provided complete data packages (Reference 29, 30) within the requirements of the U.S. EPA CLP where appropriate, for all samples. Where CLP protocols were not directly applicable, ITAS provided documentation consistent with the CLP guidelines. Upon receipt, the analytical results were reviewed by Chemical Sciences personnel for completeness and adherence to the appropriate protocols. For the dioxins and furans, the review was against the ITAS SOPs since there were no directly applicable EPA methodologies. For the inorganics and organics, review was against the appropriate Contract Compliance Screening Procedure (CCSP) where applicable. For inorganics, the CCSP used was "Contract Compliance Screening Evaluation Listing for RAS Inorganic Under SOW 784," while for organics, "Contract Compliance Screening Procedures for RAS Organics, Revised 5/86," was used.

Where review of the results by EG&G Idaho, Inc. generated questions or comments, these were summarized and submitted in writing to ITAS for resolution. ITAS responses to these comments have been factored into the review discussion presented in this section.

2. Dioxins/Furans

All of the PCDD/PCDF data, including the isomer-specific results, were reviewed. This included reviewing the chromatograms, checking calculations, checking peak ratios, checking calibrations and response factors, checking for completeness and checking the results against the appropriate ITAS SOPs (Appendix Q) to verify that they were adhered to and, in particular, that the QA/QC requirements were met.

Quality assurance summaries for the PCDD/PCDF results obtained by LRMS and HRMS are presented in Appendix U (Tables V-2 and V-3). All results were within bounds except for surrogate recovery of P₅CDF in one sample (FS-6) by low resolution and both duplicate precision and spike recovery accuracy for OCDD by high resolution. Neither of these outliers presents a significant problem. The surrogate recovery for the P₅CDF was not significantly out-of-bounds. Furthermore, P₅CDF was not detected in any of the samples, so it was not of particular concern in any event. The outliers associated with OCDD may have been caused by low levels of background OCDD contamination as found in some laboratory blanks. In any event, OCDD was not of particular concern since its presence at low levels in various samples had been previously ascribed as possible because of similar background contamination.

In summary, all of the ITAS PCDD/PCDF results were evaluated as being acceptable within the guidelines of the standard operating procedures used.

3. Volatile Organics

The volatiles data were reviewed against the guidelines and requirements of the organics CCSP referenced previously. This review included checks for completeness, adherence to protocols and selected checks of calculations.

Instrument instability required recalibration and delays the analysis of VOST-1-C, 2-C, and 3-C until 6 days past the 14 day period from receipt. However, the results are similar to those for runs VOST 5-C and 6-C, which were run within this holding time. No other deficiencies were noted.

In summary, the ITAS VOST results were evaluated as being acceptable. The violation of holding times was not considered to have significant adverse impact on the results.

4. Polynuclear Aromatic Hydrocarbons

As with the previous organics data, the PAH data was reviewed against the requirements of the organics CCSP referenced previously.

Feedstock soil samples AA5912 (FS-1), AA5913 (FS-2), AA5918 (FS-1 QC), and AA5919 (FS-1 QC) were filtered using an 0.45 μm syringe filter before injection onto the HPLC column. Due to the matrix of the samples, they were prepped and concentrated to approximately 5 mL in acetone. They were then brought to a 10 mL volume using HPLC grade acetonitrile. Samples AA5913, AA5918, and AA5919 could be injected on column at no lower a volume than 1 to 10 mL. This, plus the initial high volume of extract, multiplied the detection limit by a factor of 100.

Feedstock soil samples AA6432 (FS-6) and AA6434 (FS-5) could be injected at no lower a dilution than one to one hundred due to matrix problems. The samples contained an "impurity" that adhered to the HPLC column and required prolonged organic solvent flushes to remove it, although even after subsequent removal and reconditioning, column efficiency was diminished. At this dilution, the problem was not so severe. This high dilution combined with the larger extract volume (10 mL) raised the detection limit by a factor of 1000.

In summary, the ITAS PAH results were evaluated as acceptable.

5. Extractable Organics (Bases/Neutrals/Acids)

The base/neutral/acid (BNA) extractable organics data were reviewed similarly to the other organics results. Water samples ENT-5, ENT-6, POTW, CW, WB1, along with WB1 matrix spikes, were analyzed and found to have low acid surrogate recoveries. These samples were reextracted and reanalyzed with acceptable surrogate results. These data were submitted; however, the reextraction was performed outside the usual sample holding time.

In conclusion, the ITAS BNA results were evaluated as being acceptable. The fact that the reextraction of the samples noted above was outside the usual sample holding time was not judged to have significant adverse impact on the results.

6. Pesticides and PCBs

Analysis of pesticides was limited to only toxaphene because presence of other pesticides was ruled out, based on previous findings. These analyses were performed in six different groups referred to as Case EGG 23548, 23549, 23550, 23609, 23610, and 23612. Review of the toxaphene and PCB data was compared with guidelines of the organics CCSP.

During the analysis of ENT-B, -1, and -2 samples (Case EGG 23548), the inearity of toxaphene and Aroclor 1016/1260 mix was run at the beginning of the run. Evaluation B was run at the beginning and after the fifth sample of the run to check for column degradation. The medium level Aroclor 1016/1260 standard and the medium-level toxaphene standard were run at the end. No other exceptions were observed.

For the VOST composite samples (Cases EGG 23549 and 23612), the detection limits were either calculated values or calculated from water Contract Required Detection Limits (CRDLs). No method QC samples were prepped for these analyses. Also, no surrogate was added to these samples.

In summary, the ITAS toxaphene and PCB results were evaluated as being acceptable.

7. Herbicides

Review of the herbicide data was performed in the same manner as that used for the other organics results discussed previously.

The detection limits for soil samples were increased due to matrix interferences. The low level soil and water samples were reprepored in an

effort to eliminate these interferences. The interference was determined to be from two different sources. Glassware used to prep the soil samples was found to cause interference due to some sort of residue present. This exhibited itself as a large-solvent-type peak at the beginning of the chromatograms. The second source of interference was the feedstock samples themselves. These samples contained such high levels of herbicide that any glassware used to prep them exhibited carryover even after the glassware had been washed and the solvent had been rinsed. The carryover problem was solved by acid washing, high temperature annealing, and additional solvent rinsing.

In summary, the herbicide data were considered to be acceptable.

8. Inorganics

Review of the inorganics data was performed against the guidelines and requirements of the inorganics CCSP referenced previously to the extent that the guidelines were applicable. No comments resulted from the review. The ITAS data were complete and acceptable as submitted.

The analysis for the presence of cacodylic acid was based upon determination of arsenic in an organic compound by analysis for total arsenic. A verification of the method was performed in which 0.5 grams of $(CH_3)_2AsO_2Na \cdot 3H_2O$ were prepared as if the solid were a client submitted solid. The results for arsenic analysis are as follows:

<u>Observed (ppm)</u>	<u>Theoretical (ppm)</u>	<u>% Recovery</u>
1067	877	122

The spike recovery was considered acceptable to confirm the approach.

The following elements were labeled as in nonconformance with respect to spike recovery:

<u>Element</u>	<u>Lab ID #</u>	<u>Sample ID</u>	<u>Matrix</u>
Pb	AA6455/AA6455-spike	ENT-5	Liquid
Hg	AA6455/AA6455-spike	ENT-5	Liquid
Se	AA6455/AA6455-spike	ENT-5	Liquid
As	AA5920/AA5927	FS-1	Solid

Low recovery factor for the single standard addition method were observed during mercury analysis for the ENT-5 spike. A spike of 0.004 ppm mercury was added because the normal spike of 0.001 ppm could not be seen.

The following elements were labeled as in nonconformance with respect to duplicate preparation:

<u>Element</u>	<u>Lab ID #</u>	<u>Sample ID</u>	<u>Matrix</u>
Hg	AA6455/AA6455-spike	ENT-5	Liquid
Hg	AA5920/AA5927	FS-1	Solid
Pb	AA5920/AA5927	FS-1	Solid

Both the spike recovery and duplicate nonconformance were considered to have no significant impact on the metals results. The ITAS inorganics results were considered as acceptable.

9. Conclusions

The PCDD/PCDF results were evaluated as being acceptable within the guidelines of the standard operations procedures used after the EG&G Idaho comments were addressed by ITAS. Organic and inorganic results were evaluated as being acceptable.

Violation of holding times for three VOST samples and five reextractions of extractable organics were not judged to have significant impact on the results where this occurred.

C. ANALYTICAL RESULTS

The sample analytical results are presented in the following order: test feedstock, treated soil (ash drag), stack gas, effluent neutralization tank liquid, boiler water blowdown, water supply, liquid to the POTW, and ambient air filter samples. Where appropriate, data have been combined in tables for comparison of results. Significant ITAS data sheets are included in Appendices T and U for dioxins/furans and organics/inorganics, respectively. Detailed data sheets, graphs, procedures, and quality assurance records are included in the data packages submitted by ITAS to EG&G Idaho (References 29, 30).

1. Soil Feedstock

a. PCDD/PCDF

The PCDD and PCDF results (tetra, penta, hexa congeners*) for the soil feedstock used in the five incinerator test burns are shown in Table 13. The concentrations of 2,3,7,8-TCDD and total TCDD dominated all other PCDD/PCDF congeners. The 2,3,7,8-TCDD averaged 44 ppb and ranged from 36 to 56 ppb. The total TCDD averaged 46 ppb and ranged from 32 to 61 ppm. The 2,3,7,8-TCDD and total TCDD concentrations for the five samples are shown below to indicate the variability for the test burns. Amounts less than 1.2 ppb total TCDF were also detected. Neither the penta nor hexa congeners were detected; however, detection limits ranged up to 0.96 ppb.

TCDD	Concentration (ppb)				
	FS-1	FS-2	FS-3	FS-5	FS-6
2,3,7,8	32.0	56.0	36.0	50.0	45.8
Total	32.1	54.1	38.0	45.8	60.6

* For hepta and octa congener data, see ITAS data sheets in Appendix S.

Table 13. Polychlorodibenz-p-dioxin and polychlorodibenzofuran concentrations in incineration test burns 1, 2, 3, 5 and 6
soil feedstock and treated soil samples

PCDD/PCDF	Concentration ^a (ppb)					
	Test Burn 1		Test Burn 2		Test Burn 3	
	FS-1 ^b	AD-1 ^c	FS-2 ^b	AD-2 ^c	FS-3 ^b	AD-3 ^c
<u>Dioxins</u>						
Total TCDD	32.1	<0.0005 ^d	54.1	<0.0015 ^d	38.0	<0.0009 ^d
2,3,7,8-TCDD	32.0 ^e	<0.0011 ^f	56.0 ^g	<0.0044 ^h	36.0 ^g	<0.0017 ^h
Total PCDD	<0.15 ^d	<0.0018	<0.28 ^d	<0.0029	<0.28 ^d	<0.0303
Total HCDD	<0.06	<0.0054	<0.10	<0.0014	<0.18	<0.0022
<u>Furans</u>						
Total TCDF	0.45	<0.0009	0.49	0.0129	0.58	0.0160
2,3,7,8-TCDF	0.15	<0.0022	0.16	0.0049	<0.2	0.0054
Total PCDF	<0.23	<0.0022	<0.15	<0.0007	<0.14	<0.0013
Total HCDF	<0.08	<0.0003	<0.06	<0.0006	<0.02	<0.0007

a. See Appendix S, Exhibits 5 and 6, for ITAS data sheets.

b. Sample ID: FS = Soil Feedstock; analysis by HRGC/LRMS.

c. Sample 10: AD = Ash Drag ('Treat' Soil); analysis by HRGC/LRMS.

d. Not detected. Detection limit value shown.

e. Percent accuracy 37Cl-ICDD = 89 percent.

f. Percent accuracy 37Cl-ICDD = 102 percent; Test Burn 3 = 116 percent; Test Burn 5 = 89 percent; Test Burn 6 = 105 percent.

g. Feedstock percent accuracy 37Cl-ICDD: Test Burn 2 = 96 percent; Test Burn 3 = 94 percent; Test Burn 5 = 107 percent; Test Burn 6 = 88 percent.

h. Ash Drag percent accuracy 37Cl-ICDD: Test Burn 2 = 102 percent; Test Burn 3 = 116 percent; Test Burn 5 = 89 percent; Test Burn 6 = 105 percent.

b. Organics

The analytical results for organic compounds for the five test burns are shown in Table 14. Of the 16 acid extractable semivolatile organics investigated, only 2,4,5-trichlorophenol was found at concentrations exceeding 1 ppm, and was detected in all five feedstock samples with a range of 1.6 to 8.8 ppm.

Of the seven PAHs investigated, three PAHs were detected in the ppb range in at least one sample; however, the results shown below vary considerably, which may be due in part to the detection limit values (DLVs) for some samples.

PAH	Concentration (ppb)				
	FS-1	FS-2	FS-3	FS-5	FS-6
Fluoranthene	9.1	110	<40	100	<84
Benzo(b)fluoranthene	2.9	44	<40	50	<29
Benzo(a)pyrene	2.0	<40	<40	<45	<45

None of the eight base/neutral extractable semivolatile organics were detected although DLV for benzidine was either 2.6 or 5.3 ppm. The DLVs for the other compounds were less than 1 ppm. None of the feedstock samples showed any indication of toxaphene or the seven PCBs investigated. The DLVs were well below 1 ppm.

As expected the two herbicide components for agent orange, 2,4-D and 2,4,5-T, were detected in all five feedstock samples; however, the data summarized below from Table 14 exhibit considerable variability. The TCDD concentrations in the same feedstock samples exhibited similar but less pronounced high-low trends as the herbicides.

Table 14. Organic compound concentrations in incineration test burns 1, 2, 3, 5, and 6 soil feedstock and treated soil samples

Compound	Concentration ^a (ppm) ^b					
	Test Burn 1		Test Burn 2		Test Burn 3	
	FS-1 ^c	AD-1 ^d	FS-2 ^c	AD-2 ^d	FS-3 ^c	AD-3 ^d
<u>Acid Extractable</u>						
2,4-Dichlorophenol	<0.66 ^e	<0.33 ^e	<0.22 ^e	<0.33 ^e	<0.23	<0.33 ^e
2,5-Dichlorophenol	<0.66	<0.33	<0.66	<0.33	<0.33	<0.33
2,6-Dichlorophenol	<0.66	<0.33	<0.66	<0.33	<0.33	<0.33
3,4-Dichlorophenol	<0.66	<0.33	<0.66	<0.33	<0.33	<0.33
4,6-Dinitro-o-cresol	<3.20	<1.60	<3.20	<1.60	<1.60	<1.60
2,4-Dinitrophenol	<3.20	<1.60	<3.20	<1.60	<1.60	<1.60
2-Methylphenol	<0.66	<0.33	<0.66	<0.33	<0.33	<0.33
3-Methylphenol	<0.66	<0.33	<0.66	<0.33	<0.33	<0.33
4-Methylphenol	<0.66	<0.33	<0.66	<0.33	<0.33	<0.33
4-Nitrophenol	<3.20	<1.60	<3.20	<1.60	<1.60	<1.60
Phenol	<0.66	<0.33	<0.66	<0.33	<0.33	<0.33
2,3,4,5-Tetrachlorophenol	<0.66	<0.33	<0.66	<0.33	<0.33	<0.33
2,3,4,6-Tetrachlorophenol	<0.66	<0.33	<0.66	<0.33	<0.33	<0.33
2,3,4-Trichloropheno	<0.66	<0.33	<0.66	<0.33	<0.33	<0.33
2,4,5-Trichloropheno	1.60	<1.60	3.70	<1.60	3.60	<1.60
2,4,6-Trichloropheno	<0.66	<0.33	<0.66	<0.33	<0.33	<0.33
<u>Polyfunctional Aromatic Hydrocarbons</u>						
Benz(a)anthracene	<2.0 ppb	<2.0 ppb	<40 ppb	<2.0 ppb	<40 ppb	<2.0 ppb
Benz(a)pyrene	2.0 ppb	<2.0 ppb	<40 ppb	<2.0 ppb	<40 ppb	<2.0 ppb
Denc(c) fluoranthene	2.9 ppb	<2.0 ppb	44 ppb	<2.0 ppb	<2.0 ppb	50 ppb
Chrysene	<1.0 ppb	1.7 ppb	<44 ppb	<1.0 ppb	<40 ppb	2.1 ppb
Obenzo(a,n)anthracene	<1.0 ppb	<3.0 ppb	<40 ppb	7.6 ppb	<40 ppb	6.9 ppb
Fluoranthene	9.1 ppb	2.3 ppb	110 ppb	2.7 ppb	<40 ppb	2.1 ppb
Indeno (1,2,3-c,d)pyrene	<3.0 ppb	<3.0 ppb	<40 ppb	<3.0 ppb	<40 ppb	100 ppb
<u>Base/Neutral Extractable--Other</u>						
Benzidine	<5.30	<2.60	<5.30	<2.60	<2.60	<2.60
bis(2-chloroethoxy)methane	<0.66	<0.33	<0.66	<0.33	<0.33	<0.33
bis(2-chloroisopropyl)ether	<0.66	<0.33	<0.66	<0.33	<0.33	<0.33
3,3'-Dichlorobenzidine	<1.30	<0.66	<1.30	<0.66	<0.66	<0.66
2,4-Dinitrotoluene	<0.66	<0.33	<0.66	<0.33	<0.33	<0.33

Table 14. (continued)

Compound	Concentration ^a (ppm) ^b					
	Test Burn 1		Test Burn 2		Test Burn 3	
	FS-1 ^c	AJ-1 ^d	FS-2 ^c	AD-2 ^d	FS-3 ^c	AD-3 ^d
N-Nitrosodimethylamine	<0.66 ^e	<0.33 ^e	<0.66 ^e	<0.33 ^e	<0.33 ^e	0.33 ^e
1,2,3,5-Tetrachlorobenzene	<0.66	<0.33	<0.66	<0.33	<0.33	<0.33
1,2,4,5-Tetrachlorobenzene	<0.66	<0.33	<0.66	<0.33	<0.33	<0.33
<u>Organochlorine Pesticides/PCBs</u>						
Toxaphene	<0.17	<0.20	<0.18	<0.21	<0.17	<0.21
PCB 1016	<0.086	<0.098	<0.088	<0.011	<0.087	<0.10
PCB 1221	<0.086	<0.098	<0.088	<0.011	<0.087	<0.10
PCB 1232	<0.086	<0.098	<0.048	<0.011	<0.087	<0.68
PCB 1242	<0.086	<0.098	<0.059	<0.011	<0.087	<0.10
PCB 1248	<0.086	<0.098	<0.088	<0.011	<0.087	<0.10
PCB 1254	<0.17	<0.20	<0.18	<0.21	<0.17	<0.10
PCB 1260	<0.17	<0.20	<0.18	<0.21	<0.17	<0.10
<u>Herbicides</u>						
2,4-D	56	<0.020	3300	<0.020	120	<0.020
2,4,5-T	100	<0.002	510	<0.002	220	<0.002
					47	<0.002
						840
						<0.002

a. See Appendix 1, Exhibits 3, 4, and 5, for ITAS data sheets.

b. Units unless shown otherwise.

c. Sample ID: FS = Soil Feedstock; analysis by HRGC/IRMS.

d. Sample ID: AD = Ash Drag (Treated Soil); analysis by HRGC/HRMS.

e. Not detected. Detection limit value shown.

<u>Herbicide</u>	Concentration (ppm)				
	<u>FS-1</u>	<u>FS-2</u>	<u>FS-3</u>	<u>FS-5</u>	<u>FS-6</u>
2,4-D	56	3300	120	23	400
2,4,5-T	100	510	220	47	840

c. Inorganics

The analytical results for nine inorganics for the five test burns are shown in Table 15. The dominant element was barium ranging in concentration from 23 to 61 ppm. Other elements detected in concentrations greater than 1 ppm were lead (10 ppm max in one sample), arsenic, chromium, and nickel (in only two samples).

2. Treated Soil

a. PCDD/PCDF

Table 13 compares the PCDD and PCDF results for the treated soil with results of the feedstock for the five test burns. No PCDD (tetra, penta, and hexa congeners) was detected in any of the treated soil samples. The DLVs varied from 0.0001 and 0.0054 ppb giving indication of the HRMS performance. The 2,3,7,8-TCDD also was not detected with DLVs ranging from 0.0011 to 0.0026 ppb.

Total TCDF and 2,3,7,8-TCDF were detected in four of the five treated soil samples (AD-2, -3, -5, and -6). However, the detected total TCDF varied only from 0.0067 to 0.0160 ppb and the detected 2,3,7,8-TCDF varied only from 0.0021 to 0.0054 ppb. The DLVs for the other run were 0.0009 ppb for total TCDF and 0.0022 ppb for 2,3,7,8-TCDF. These data show the detection levels and DLVs are in the same range and apparently sensitive to the setups for the individual analysis runs. No P₅CDF or H_xCDF congeners were detected in any of the five treated soil samples with the DLVs ranging between 0.0002 and 0.0069 ppb.

Table 15. Inorganic concentrations in incineration test burns 1, 2, 3, 5, and 6 soil feedstock and treated soil samples

Element	Concentration ^a (mg/kg or ppm)					
	Test Burn 1		Test Burn 2		Test Burn 3	
	FS-1 ^b	AD-1 ^c	FS-2 ^b	AD-2 ^c	FS-3 ^b	AD-3 ^c
Arsenic	8.2	3.6	5.5	2.7	9.8	3.9
Barium	31.0 ^d	30.0 ^d	61.0	24.0	39.0	48.0
Cadmium	<0.20 ^e	<0.20 ^e	<0.20 ^e	<0.20 ^e	<0.20 ^e	<0.20 ^e
Chromium	8.1	4.1	8.4	4.9	7.3	7.6
Lead	10.0	3.4	7.0	4.2	12.0	4.0
Mercury	0.04	<0.02	<0.02	<0.02	0.03	0.12
Nickel	<2.0	<2.0	2.1 ^d	1.8 ^d	<2.0	2.6 ^d
Selenium	<0.20	0.20	<0.20	<0.20	<0.20	<0.20
Silver	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02

a. See Appendix I, Exhibit 6, for ITAS data sheets.

b. Sample ID: FS = Soil Feedstock; analysis by HRGC/LRMS.

c. Sample ID: AD = Ash Drag (Treated Soil); analysis by HRGC/HRMS.

d. Detected, but at a level less than the required detection limit. This is an estimated value.

e. Not detected. Detection limit value shown.

Considering the concentration results for only the tetra-, penta-, and hexa-congeners of PCDD and PCDF (and neglecting use of weighting factors because of possible co-elution), the following sums of detection levels or DLVs are shown for the five test burns. All results are well within the AFESC's 1 ppb goal (Section I.A).

<u>Test Burn</u>	<u>Sample</u>	PCDD/PCDF Congener Concentration Sum (ppb)
1	AD-1	<0.0091
2	AD-2	<0.0200
3	AD-3	<0.0214
5	AD-5	<0.0106
6	AD-6	<0.0170

b. Organics

Table 14 compares the organic compound results for the treated soil with results for the feedstock for the five test burns. None of the 16 acid-extractable semivolatile organics investigated was detected with DLVs generally well below 1 ppm, except for three which were 1.60 ppm. 2,4,5-trichlorophenol, detected in the feedstock of all five test burn samples, but was not detected with DLVs at 1.60 ppm, except for one sample positive result which was 0.21 ppm.

Of the seven PAHs investigated, four PAHs were detected in the ppb range in at least one sample. With three exceptions, the results shown below present concentrations within the general range of the DLVs for all five samples (1.0-3.0 ppb). Some reduction in concentration is shown compared to the feedstock data.

PAH	Concentration (ppb)				
	AD-1	AD-2	AD-3	AD-5	AD-6
Dibenzo(a,h)anthracene	<3.0	7.6	6.9	<2.1	3.4
Fluoranthene	2.3	2.7	2.1	3.7	6.3
Chrysene	1.7	<1.0	2.1	<1.0	<1.0
Benzo(a)anthracene	<2.0	<2.0	<2.0	<1.0	1.2

None of the eight base/neutral extractable semivolatile organics were detected in the treated soil samples, which was also the case for the feedstock. The DLVs were less than 1.0 ppm except for benzidine, which was 2.60 ppm in all five samples. Similarly, none of the samples showed any indication of toxaphene or the seven PCBs investigated, with the DLVs well below 1 ppm.

Whereas the feedstock samples exhibited large concentrations of the herbicides 2,4-D and 2,4,5-T, none was detected in any of the five treated soil samples. The DLVs for 2,4-D and 2,4,5-T were 0.020 ppm and 0.002 ppm, respectively, for all five samples.

c. Inorganics

Table 15 compares the inorganic metals results for the treated soil for the five test burns. Barium remained the dominant element with a concentration ranging from 12 to 48 ppm, which is only slightly less than shown in the feedstock samples. Because treated soil samples showed both increases and decreases compared to the respective feedstock sample concentrations, the variations are considered due more to variability in the sampling and analysis than to the process. Some reduction in concentrations of arsenic and lead were observed in the treated soil samples compared to the feedstock samples. But, because the feedstock sample concentrations were low (≤ 12 ppm), any indicated trend may be incidental.

d. Other

The five treated soil samples were additionally analyzed for cyanide, chloride, and sulfide. The concentrations are shown in Table 16. Because cyanide was detected in three of the samples (0.70-1.0 ppm), an EP toxicity test for cyanide was performed and was not detected at a DLV of 0.01 µg/L (ppb). The sulfides ranged from 34 to 110 ppm. the pH of the treated soil is shown to be basic and in a fairly narrow range (10.74-11.99). This basic tendency is likely due to the large amount of oyster shell (CaO) in the site area that was used to stabilize identified HO spills during the storage operations.

3. Stack Gas

a. PCDD/PCDF

The PCDD/PCDF concentration results (tetra, penta, and hexa congeners^a) for the stack gas MM5 XAD samples from the five test burns are shown in Table 17. None of these PCDD congeners were detected, including the specific analysis for 2,3,7,8-TCDD. DLVs ranged between 0.02 and 0.48 ng/m³.

Total TCDF was detected in samples VB-3 and VB-6 at 1.55 and 5.27 ng/m³, respectively. DLVs for the other three samples were 0.17, 0.14, and 0.56 ng/m³. 2,3,7,8-TCDF was detected in samples VB-2 and VB-6 at 0.33 and 1.17 ng/m³. DLV's for the other three samples were 0.23, 1.45, and 0.80 ng/m³. None of the penta and hexa congeners was detected with DLVs ranging between 0.01 and 0.37 ng/m³.

a. For hepta and octa congener data, see ITAS data sheets in Appendix S.

Table 16. Cyanide and sulfide concentrations and pH in treated soil samples for test burns.

<u>Test Burn/ Sample</u>	Concentration ^a			
	<u>Cyanide^b (ppm)</u>	<u>Cyanide(EP)^c (µg/L)</u>	<u>Sulfide (ppm)</u>	<u>pH</u>
1 (AD-1)	<0.50 ^d	NA ^e	110	11.55
2 (AD-2)	<0.50	NA	93	10.74
3 (AD-3)	1.00	<0.01 ^f	70	11.10
5 (AD-5)	0.70	<0.01	110	11.99
6 (AD-6)	0.70	<0.01	34	10.82

a. See Appendix T, Exhibit 8, for ITAS data sheet.

b. Standard cyanide analysis as described in Section V.A.7.C.

c. Indicates the CN analysis in the EP toxicity test.

d. Not detected. Detection limit value shown.

e. NA means not analyzed. None was requested.

f. EP toxicity test for cyanide was performed when CN was detected by the standard test in the treated soil sample.

Table 17. Polychlorodibenzo-p-dioxin and polychlorodibenzofuran concentrations in incinerator stack gas samples from test burns (corrected to standard conditions)

PCDD/PCDF	Concentration by Test Run ^a (ng/m ³)				
	<u>1^b</u>	<u>2^c</u>	<u>3^d</u>	<u>5^e</u>	<u>6^f</u>
<u>Dioxins</u>					
Total TCDD	<0.15 ^g	<0.14 ^g	<0.03 ^g	<0.02 ^g	<0.21 ^g
2,3,7,8-TCDD	<0.22	<0.26	<0.23	<0.25	<0.27
Total P ₅ CDD	<0.16	<0.05	<0.48	<0.29	<0.17
Total H _x CDD	<0.11	<0.03	<0.10	<0.03	<0.03
<u>Furans</u>					
Total TCDF	<0.17	<0.14	1.55	<0.56	5.27
2,3,7,8-TCDF	<0.23	0.33	<1.45	<0.80	1.17
Total P ₅ CDF	<0.02	<0.04	<0.01	<0.13	<0.15
Total H _x CDF	<0.03	<0.04	<0.37	<0.08	<0.07

a. See Appendix S, Exhibits 5 and 6, for ITAS data sheets.

b. Sample ID: VB-1-Filter; composite of Samples VB-1-F, VB-1-XAD, VB-1-PW, and VB-1-C.

c. Sample ID: VB-2-Filter; composite of Samples VB-2-F, VB-2-XAD, VB-2-PW, and VB-2-C.

d. Sample ID: VB-3-Filter; composite of Samples VB-3-F, VB-3-XAD, VB-3-PW, and VB-3-C.

e. Sample ID: VB-5-Filter; composite of Samples VB-5-F, VB-5-XAD, VB-5-PW, and VB-5-C.

f. Sample ID: VB-6-Filter; composite of Samples VB-6-F, VB-6-XAD, VB-6-PW, and VB-6-C.

g. Not detected. Detection limit value shown.

b. Organics

The organic compound concentration results for the stack gas samples (VOST and MM5) from the five test burns are shown in Table 18. Of 16 volatiles investigated in the analysis of the VOST samples, large concentrations of acetone and significant concentrations of methylene chloride and chloroform were observed. All were attributed to contamination in either the field sampling (acetone) or the laboratory analysis (methylene chloride and chloroform). Most of the remaining volatiles were detected in at least one sample, with toluene showing the highest concentration in sample VOST-2-C(34.3 $\mu\text{g}/\text{m}^3$).

Of the 16 acid extractable semivolatile organics investigated, only phenol was detected and this occurred in all five test burn samples at values of either 30 or 40 $\mu\text{g}/\text{m}^3$. The DLVs for the remaining compounds were either 7 or 35 $\mu\text{g}/\text{m}^3$.

All seven PAHs investigated were detected in the stack gas samples. The maximum concentrations occurred in samples from Test Burn 5: indeno(1,2,3-c,d)pyrene at 22 mg/m^3 , benzo(b)fluoranthene at 18.5 mg/m^3 , and benzo(a)pyrene at 13.9 mg/m^3 represent compounds in excess of 10 mg/m^3 .

None of the base/neutral extractable semivolatiles (8), toxaphene and PCBs (7), or herbicides 2,4-D and 2,4,5-T was detected in any of the test burn stack gas samples. The DLV ranges were as follows:

<u>Organic Compound</u>	<u>DLV Range ($\mu\text{g}/\text{m}^3$)</u>
Base/neutral extractable	7-57
Toxaphene	0.78-5.10
PCBs	0.35-10.90
2,4-D	0.0007-0.0023
2,4,5-T	0.0001-0.0007

Table 18. Organic compound concentrations in the incinerator stack gas samples from test burns
(corrected to standard condition)

Volatile Organics ^g	Compound	Concentration by Test Run ^a ($\mu\text{g/m}^3$)			
		^b	^c	^d	^e
Chloromethane	<?	<?	<?	<?	1.04
Methylene chloride	132 ^j	260 ^j	8.8 ^j	2.02 ^j	
Acetone	13,700 ^k	31,800 ^k	491 ^k	124 ^k	
Carbon Disulfide	3,14 ^j	3,08 ^j	3.79 ^j	1.76 ^j	
Chloroform	180 ^j	434 ^j	2.78 ^j	1.19 ^j	
2-Butanone	14.5	19.4	51.0	13.1	
1,1,1-Trichloroethane	0.66	<?	<?	0.45	
Carbon tetrachloride	0.24	<?	<?	0.23	
Bromo dichloromethane	<?	0.59	0.24	<?	
Dibromo dichloromethane	<?	0.10	<?	<?	
Benzene	6.20	8.14	3.09	4.02	
1,1,1-Trichloroethene			27.6	3.26	
Toluene	15.5	34.3	23.1	8.03	
Ethy benzene	0.77	1.04	0.88	1.04	
Stryrene	6.18	7.00	14.1	4.10	
Total Xylene	3.29	2.51	4.16	6.70	
<u>Acid Extractable Semivolatile^l</u>					
2,4-Dichloropheno ^l	<?	<?	<?	<?	<?
2,5-Dichloropheno ^l	<?	<?	<?	<?	<?
2,6-Dichloropheno ^l	<?	<?	<?	<?	<?
3,4-Dichloropheno ^l	<?	<?	<?	<?	<?
4,6-Dinitro-o-cresol ^l	<35	<35	<35	<35	<35
2,4-Dinitropheno ^l	<35	<35	<35	<35	<35
2-Methylpheno ^l	<?	<?	<?	<?	<?
3-Methylpheno ^l	<?	<?	<?	<?	<?
4-Methylpheno ^l	<?	<?	<?	<?	<?
4-Nitropheno ^l	<35	<35	<35	<35	<35

Table 18. (continued)

Compound	Concentration by Test Run ^a ($\mu\text{g}/\text{m}^3$)					
	^b	^c	^d	^e	^f	
Phenol						
2,3,4,5-Tetrachloropheno ^l	40 <7 ^h	40 ^h	30 ^h	30 ^h	40 ^h	
2,3,4,6-Tetrachloropheno ^l	<7	<7	<7	<7	<7	
2,3,4-Trichloropheno ^l	<7	<7	<7	<7	<7	
2,4,5-Trichloropheno ^l	<35	<35	<35	<35	<35	
2,4,6-Trichloropheno ^l	<7	<7	<7	<7	<7	
<u>Polynuclear Aromatic Hydrocarbons</u>						
Benz(a)anthracene	350	2,510	920	840	850	
Benz(a)pyren	920	6,700	5,280	13,900	1,950	
Benz(b)fluoranthene	3,120	9,210	7,240	18,500	4,200	
Chrysene	130	2,010	1,030	1,850	1,560	
Dibenz(a,h)anthracene	<20	6,280	2,590	5,570	3,610	
Fluoranthene						
Indeno[1,2,3-c,d]pyrene	2,200	2,410	1,140	1,620	1,080	
Indeno[1,2,3-c,d]pyrene	3,120	2,830	3,210	22,000	5,460	
<u>Base/Neutral Extractable--Other</u>						
Renzidine	<57	<57	<57	<57	<57	
bis(2-chloroethoxy)methane	<7	<7	<7	<7	<7	
bis(2-chloroisopropyl)ether	<7	<7	<7	<7	<7	
3,3'-Ochrlorobenzidine	<14	<14	<14	<14	<14	
2,4-Dinitrotoluene	<7	<7	<7	<7	<7	
N Nitrosodimethylamine	<7	<7	<7	<7	<7	
1,2,3,5-Tetrachlorobenzene	<7	<7	<7	<7	<7	
1,2,4,5-Tetrachlorobenzene	<7	<7	<7	<7	<7	
<u>Organochlorine Pesticides/PCBs</u>						
Toxaphene	<0.78	<1.14	<1.14	<1.10	<2.15	
PCB 1016	<0.35	<0.52	<0.52	<1.74	<0.73	
PCB 1221	<0.66	<9.84	<9.72	<10.90	<9.17	
PCB 1232	<0.35	<0.52	<0.52	<1.16	<0.50	
PCB 1242	<0.35	<0.52	<0.52	<0.67	<0.49	

Table 18. (continued)

Compound	Concentration by Test Run ^a ($\mu\text{g/lm}$)					
	^b	^c	^d	^e	^f	
<u>Organochlorine Pesticides/PCBs {continued}</u>						
PCB 1248	<0.35 ^h	<0.52 ^h	<0.52 ^h	<0.63 ^h	<0.63 ^h	
PCB 1254	<0.71	<1.05	<1.03	<1.85	<1.85	
PCB 1260	<0.71	<1.05	<1.03	<4.41	<4.41	
<u>Herbicides</u>						
2,4-D	<0.0007	<0.0011	<0.0012	<0.0010	<0.0010	
2,4,5-T	<0.0002	<0.0001	<0.0007	<0.0006	<0.0003	

^a. See Appendix, Exhibits 3, 4, 5, and 7, for ITAS data sheets.
^b. Sample ID: VOST-1-C for volatile organics; V8-1-XAD for other organics.
^c. Sample ID: VOST-2-C for volatile organics; V8-2-XAD for other organics.
^d. Sample ID: VOST-3-C for volatile organics; V8-3-XAD for other organics.
^e. Sample ID: VOST-5-C for volatile organics; V8-5-XAD for other organics.
^f. Sample ID: VOST-6-C for volatile organics; V8-6-XAD for other organics.
^g. Each analyzed VOST sample was a composite of three sample pairs.
^h. Not detected. Detection limit value shown.
ⁱ. Composite sample was lost due to clogged transfer line in desorber affecting two of the three sample pairs in the desorber. Data was not reported.
^j. Suspect laboratory contamination. Methylene chloride and chloroform are routinely used at the ITAS laboratory.
^k. Suspect field sampling contamination. Acetone was used as rinse solvent for glassware that was cleaned in the field.

c. Chloride

Chloride was detected in all five stack gas samples at concentrations as listed below:

<u>Sample</u>	<u>Concentration^a ($\mu\text{g}/\text{m}^3$)</u>
VB-1	0.15
VB-2	0.06
VB-3	0.16
VB-5	0.29
VB-6	0.15

d. Particulate

Particulates were detected in all five stack gas samples at amounts and concentrations as listed below:

<u>Sample</u>	<u>Total^b (mg)</u>	<u>Concentration^b (mg/m^3)</u>
VB-1	24.1	17.2
VB-2	40.8	42.7
VB-3	35.4	36.6
VB-5	41.2	47.8
VB-6	44.1	43.0

a. See Appendix T, Exhibit 8, for ITAS data sheet.

b. See Appendix P, for detailed field data.

4. Effluent Neutralization Tank Solution Samples

a. PCDD/PCDF

The PCDD/PCDF concentration results (tetra, penta, and hexa congeners^b) for the effluent neutralization tank solution samples from the four test burns that were analyzed (Test 3 was not submitted) are shown in Table 19. None of the PCDD/PCDF congeners was detected, including the specific analysis for 2,3,7,8-TCDD/TCDF. The DLVs ranged from 0.001 to 0.057 parts per trillion (ppt).

b. Organics

The organic compound concentration results for the effluent neutralization tank solution samples from the four test burns are shown in Table 20. None was detected except for two PAHs: 0.073 µg/L of dibenzo(a,h)anthracene in Sample ENT-1 and 0.013 µg/L of benzo(a)anthracene in Sample ENT-5. The DLV ranges for the different organic compound types were as follows:

<u>Organic Compound</u>	<u>DLV Range (µg/L)</u>
Acid extractable	10-50
PAHs	0.013-0.21
Base/neutral extractable	10-80
Toxaphene	1.0
PCBs	0.5-1.0
2,4-D	1-3
2,4,5-T	0.1-1.7

a. For hepta and octa congener data, see ITAS data sheets in Appendix S.

Table 19. Polychlorodibenzo-p-dioxin and polychlorodibenzofuran concentrations in the effluent neutralization tank samples from test burns

PCDD/PCDF	Concentration by Test Run ^a (ppt)				
	^b 1	^c 2	^d 3	^e 5	^f 6
<u>Dioxins</u>					
Total TCDD	<0.013 ^g	<0.031 ^g	-- ^h	<0.008 ^g	<0.019 ^g
2,3,7,8-TCDD	<0.027	<0.032	-- ^h	<0.020	<0.050
Total P ₅ CDD	<0.004	<0.041	-- ^h	<0.026	<0.006
Total H _x CDD	0.023	<0.003	-- ^h	<0.008	<0.042
<u>Furans</u>					
Total TCDF	<0.012	<0.017	-- ^h	<0.018	<0.045
2,3,7,8-TCDF	<0.037	<0.044	-- ^h	<0.057	<0.030
Total P ₅ CDF	<0.003	<0.001	-- ^h	<0.009	<0.004
Total H _x CDF	<0.003	<0.003	-- ^h	<0.013	<0.013

a. See Appendix S, Exhibits 5 and 6, for ITAS data sheets.

b. Sample ID: ENT-1.

c. Sample ID: ENT-2.

d. Sample ID: ENT-3.

e. Sample ID: ENT-5.

f. Sample ID: ENT-6.

g. Not detected. Detection limit value shown.

h. Sample not submitted for analysis.

Table 20. Organic compound concentrations in the effluent neutralization tank samples from test burns

Compound	Concentration by Test Run ^{a,b} ($\mu\text{g/L}$)			
	<u>1^c</u>	<u>2^d</u>	<u>5^e</u>	<u>6^f</u>
<u>Acid Extractable</u>				
2,4-Dichlorophenol	<10 ⁹	<10 ⁹	<10 ⁹	<10 ⁹
2,5-Dichlorophenol	<10	<10	<10	<10
2,6-Dichlorophenol	<10	<10	<10	<10
3,4-Dichlorophenol	<10	<10	<10	<10
4,6-Dinitro-o-cresol	<50	<50	<50	<50
2,4-Dinitrophenol	<50	<50	<50	<50
2-Methylphenol	<10	<10	<10	<10
3-Methylphenol	<10	<10	<10	<10
4-Methylphenol	<10	<10	<10	<10
4-Nitrophenol	<50	<50	<50	<50
Phenol	<10	<10	<10	<10
2,3,4,5-Tetrachlorophenol	<10	<10	<10	<10
2,3,4,6-Tetrachlorophenol	<10	<10	<10	<10
2,3,4-Trichlorophenol	<10	<10	<10	<10
2,4,5-Trichlorophenol	<50	<50	<50	<50
2,4,6-Trichlorophenol				
<u>Polynuclear Aromatic Hydrocarbons</u>				
Benzo(a)anthracene	<0.013	<0.013	0.013	<0.013
Benzo(a)pyrene	<0.023	<0.023	<0.023	<0.023
Benzo(b)fluoranthene	<0.018	<0.018	<0.027	<0.018
Chrysene	<0.150	<0.150	<0.150	<0.150
Dibenzo(a,h)anthracene	0.073	<0.030	<0.030	<0.030
Fluoranthene	<0.21	<0.21	<0.21	<0.21
Indeno(1,2,3-c,d)pyrene	<0.043	<0.043	<0.043	<0.043
<u>Base/Neutral Extractable--Other</u>				
Benzidine	<80	<80	<80	<80
bis(2-chloroethoxy)methane	<10	<10	<10	<10
bis(2-chloroisopropyl)ether	<10	<10	<10	<10
3,3'-Dichlorobenzidine	<20	<20	<20	<20

Table 20. (continued)

Compound	Concentration by Test Run ^{a,b} ($\mu\text{g}/\text{L}$)			
	<u>1^c</u>	<u>2^d</u>	<u>5^e</u>	<u>6^f</u>
<u>Base/Neutral Extractable--Other (continued)</u>				
2,4-Dinitrotoluene	<10 ^g	<10 ^g	<10 ^g	<10 ^g
N-Nitrosodimethylamine	<10	<10	<10	<10
1,2,3,5-Tetrachlorobenzene	<10	<10	<10	<10
1,2,4,5-Tetrachlorobenzene	<10	<10	<10	<10
<u>Organochlorine Pesticides/PCBs</u>				
Toxaphene	<1.0	<1.0	<1.0	<1.0
PCB 1016	<0.5	<0.5	<0.5	<0.5
PCB 1221	<0.5	<0.5	<0.5	<0.5
PCB 1232	<0.5	<0.5	<0.5	<0.5
PCB1242	<0.5	<0.5	<0.5	<0.5
PCB 1248	<0.5	<0.5	<0.5	<0.5
PCB 1254	<1.0	<1.0	<1.0	<1.0
PCB 1260	<1.0	<1.0	<1.0	<1.0
<u>Herbicides</u>				
2,4-D	<1.0	<1.0	<3.0	<1.0
2,4,5-T	<0.8	<1.7	<2.0	<0.1

a. See Appendix T, Exhibits 3, 4, and 5, for ITAS data sheets.

b. Sample for Run 3 was not submitted for analysis.

c. Sample ID: ENT-1.

d. Sample ID: ENT-2.

e. Sample ID: ENT-5

f. Sample ID: ENT-6

g. Not detected. Detection limit value shown.

5. Boiler Blowdown Water Samples

The inorganic concentration results for the boiler blowdown water samples from Test Burns 1, 5, and 6 (samples for burns 2 and 3 were not submitted for analysis) are shown in Table 21. Of nine inorganics investigated, nickel was clearly dominant in each sample with a very tight range of 2420 to 2760 µg/L. Lead and chromium were also observed in all three samples but at substantially lower concentrations, ranging between 17 and 49 µg/L.

6. Background Water Sample

a. PCDD/PCDF

The PCDD/PCDF concentration results (tetra, penta, and hexa congeners) for the background water sample WB-1 are shown in Table 22. None of the congeners was detected with DLVs ranging from 0.006 to 0.12 ppt.

b. Organics

The organic compound concentration results for the background water sample are shown in Table 23. None was detected with DLV ranges as shown below:

Organic Compound	DLV Range (µg/L)
Acid and base/neutral extractable	10-80
PAHs	0.013-0.15
Toxaphene/PCBs	0.5-1.0
2,4-D	1.0
2,4,5-T	0.1

Table 21. Inorganic concentrations in boiler blowdown water samples from test burns 1, 5, and 6

Element	Concentration by Test Run ^{a,b} ($\mu\text{g/L}$)		
	1 ^c	5 ^d	6 ^e
Arsenic	2.1 ^f	<1.0 ^g	<4.0 ^g
Barium	56 ^f	<20	<20
Cadmium	<1.0 ^g	<1.0	<1.0
Chromium	27	38	35
Lead	49	35	17
Mercury	0.52	<0.20	<0.20
Nickel	2650	2420	2760
Selenium	<6.0	<1.0	<1.0
Silver	<0.1	<0.1	<0.1

a. See Appendix T, Exhibit 6, for ITAS data sheets.

b. Samples for test Runs 2 and 3 were not submitted for analysis, but were kept for archive.

c. Sample ID: BB-1.

d. Sample ID: BB-5.

e. Sample ID: BB-6.

f. Detected, but at a level less than the required detection limit. This is an estimated value.

g. Not detected. Detection limit value shown.

Table 22. Polychlorodibenzo-p-dioxin and polychlorodibenzofuran concentrations in other system water samples

<u>PCDD/PCDF</u>	Concentration ^{a,e} (ppt)		
	<u>WB-1^b</u>	<u>CW^c</u>	<u>POTW^d</u>
<u>Dioxins</u>			
Total TCDD	<0.014 ^e	<0.007 ^e	<0.026 ^e
2,3,7,8-TCDD	<0.035	<0.026	<0.076
Total P ₅ CDD	<0.052	<0.059	<0.013
Total H _x CDD	<0.020	<0.023	<0.038
<u>Furans</u>			
Total TCDF	<0.012	<0.010	<0.075
2,3,7,8-TCDF	<0.059	<0.021	<0.12
Total P ₅ CDF	<0.019	<0.005	<0.007
Total H _x CDF	<0.006	<0.009	<0.025

a. See Appendix S, Exhibits 5 and 6, for ITAS data sheets.

b. Background water sample obtained from tap water used for feed water to incinerator operations.

c. Caustic water sample.

d. Sample represents treated ENT water in the POTW holding tank after all tests before discharging from the site to POTW treatment.

e. < values indicate that no constituent was detected; the detection limit value is shown.

Table 23. Organic compound concentrations in other system water samples

Compound	Concentration ^a ($\mu\text{g/L}$)		
	WB-1 ^b	CW ^c	POTW ^d
<u>Acid Extractable</u>			
2,4-Dichlorophenol	<10	<100	<10
2,5-Dichlorophenol	<10	<100	<10
2,6-Dichlorophenol	<10	<100	<10
3,4-Dichlorophenol	<10	<100	<10
4,6-Dinitro-o-cresol	<50	<500	<50
2,4-Dinitrophenol	<50	<500	<50
2-Methylphenol	<10	<100	<10
3-Methylphenol	<10	<100	<10
4-Methylphenol	<10	<100	<10
4-Nitrophenol	<50	<500	<50
Phenol	<10	<100	<10
2,3,4,5-Tetrachlorophenol	<10	<100	<10
2,3,4,6-Tetrachlorophenol	<10	<100	<10
2,3,4-Trichlorophenol	<10	<100	<10
2,4,5-Trichlorophenol	<50	<500	<50
2,4,6-Trichlorophenol	<10	<100	<10
<u>Polynuclear Aromatic Hydrocarbons</u>			
Benzo(a)anthracene	<0.013	<0.013	<0.013
Benzo(a)pyrene	<0.023	<0.023	<0.023
Benzo(b)fluoranthene	<0.018	<0.018	<0.018
Chrysene	<0.15	<0.15	<0.15
Dibenzo(a,h)anthracene	<0.030	<0.030	<0.030
Fluoranthene	<0.21	<0.21	<0.21
Indeno(1,2,3-c,d)pyrene	<0.043	<0.043	<0.043
<u>Base/Neutral Extractable--Other</u>			
Benzidine	<80	<800	<80
bis(2-chloroethoxy)methane	<10	<100	<10
bis(2-chloroisopropyl)ether	<10	<100	<10
3,3'-Dichlorobenzidine	<20	<200	<20

Table 23. (continued)

Compound	Concentration ^a ($\mu\text{g/L}$)		
	WB-1 ^b	CW ^c	POTW ^d
<u>Base/Neutral Extractable--Other (continued)</u>			
2,4-Dinitrotoluene	<10	<100	<10
N-Nitrosodimethylamine	<10	<100	<10
1,2,3,5-Tetrachlorobenzene	<10	<100	<10
1,2,4,5-Tetrachlorobenzene	<10	<100	<10
<u>Organochlorine Pesticides/PCBs</u>			
Toxaphene	<1.0	<1.0	<1.0
PCB 1016	<0.5	<0.5	<0.5
PCB 1221	<0.5	<0.5	<0.5
PCB 1232	<0.5	<0.5	<0.5
PCB 1242	<0.5	<0.5	<0.5
PCB 1248	<0.5	<0.5	<0.5
PCB 1254	<1.0	<1.0	<1.0
PCB 1260	<1.0	<1.0	<1.0
<u>Herbicides</u>			
2,4-D	<1.0	<1.0	<1.0
2,4,5-T	<0.1	<0.1	<0.1

a. See Appendix T, Exhibit 3, 4, and 5, for ITAS data sheets.

b. Background water sample obtained from tap water used for feed water to incinerator operations.

c. Caustic water sample.

d. Sample represents treated ENT water in the POTW holding tank after all tests before discharging from the site to POTW treatment.

e. <value indicate that no constituent was detected; the detection limit value is shown.

c. Inorganics

The inorganic concentration results for the background water sample are shown in Table 24. Barium and lead were detected at concentrations of 20 and 4.9 µg/L, which are low and near detection levels.

7. Caustic Water Sample

a. PCDD/PCDF

The PCDD/PCDF concentration results (tetra, penta, and hexa congeners) for the caustic water sample CW are shown in Table 22. None of the congeners was detected with DLVs ranging from 0.005 to 0.059 ppt.

b. Organics

The organic compound concentration results for the caustic water sample are shown in Table 23. None was detected with DLV ranges as shown below:

<u>Organic Compound</u>	<u>DLV Range (µg/L)</u>
Acid and base/neutral extractable	100-800
PAHs	0.013-0.21
Toxaphene/PCBs	0.5-1.0
2,4-D	1.0
2,4,5-T	0.1

Table 24. Inorganic concentrations in other system water samples

<u>Element</u>	Concentration ^a ($\mu\text{g/L}$)		
	<u>WB-1^b</u>	<u>CW^c</u>	<u>POTW^d</u>
Arsenic	<1.0 ^e	5.6 ^f	13
Barium	20	449	<204 ^e
Cadmium	<1.0	<1.0 ^e	12
Chromium	<10	32	<10
Lead	4.90 ^f	173	2.50 ^f
Mercury	<0.40	13	<0.20
Nickel	<10	<20	30 ^f
Selenium	<1.0	<60	60
Silver	<0.10	<7.0	<0.10

a. See Appendix T, Exhibit 6, for ITAS data sheets.

b. Background water sample obtained from tap water used for feed water to incinerator operations.

c. Caustic water sample.

d. Sample represents treated ENT water in POTW holding tank after all tests before discharging from the site to POTW treatment.

e. < values indicate that no constituent was detected; the detection limit value is shown.

f. Detected, but at a level less than the required detection limit. This is an estimated value.

c. Inorganics

The inorganic concentration results for the caustic water sample are shown in Table 24. Barium and lead were dominant at concentrations of 449 and 173 $\mu\text{g/L}$, respectively. Chromium, mercury, and arsenic were also observed at low concentrations.

8. POTW Composite Liquid Sample

a. PCDD/PCDF

The PCDD/PCDF concentration results (tetra, penta, and hexa congeners) for the composite liquid sample from the POTW holding tank are shown in Table 22. None of the congeners was detected with DLVs ranging from 0.007 to 0.12 ppt.

b. Organics

The organic compound concentration results for the composite liquid sample from the POTW holding tank are shown in Table 23. None were detected. The DLV ranges for the different compound types were the same as shown for the background water sample (Section V.C.6.b).

c. Inorganics

The inorganic concentration results for the composite liquid sample from the POTW holding tank are shown in Table 24. Selenium and nickel were the elements of highest detected concentrations at 60 and 30 $\mu\text{g/L}$, respectively. Arsenic, cadmium, and lead were also detected at low concentrations. Barium, which was detected in the other water samples and soil, was not detected in the POTW sample; however, the DLV was relatively high at 204 $\mu\text{g/L}$.

d. Other Characteristics

Analysis of the POTW sample for BOD and COD showed these concentrations at 2.0 and 7.7 $\mu\text{g/L}$.

9. Ambient Air Filters

Ambient air filters for four sampler setups were analyzed for the amount of 2,4-D and 2,4,5-T collected on each filter (particulate was previously discussed in Section IV.D.3). Two of the sampler setups were the PUF type in which there is a standard filter at the entrance to the sampler followed by three urethane collector plates. The top two plates were considered as one filter sample during the analysis. The concentrations of each herbicide are shown in Table 25. The data show the 2,4,5-T concentrations higher than those for 2,4-D. When summing the concentrations for the filter and the urethane plates, PUF sampler P-20 showed the highest concentration of 2,4,5-T at $<32.85 \text{ ng/m}^3$. This occurred during the soil drying activities of December 11 and 12, 1986, as compared to the other two test burn days. The average measured concentrations are significantly below the TLV of 10 mg/m^3 , which applies for both 2,4-D and 2,4,5-T (Reference 25).

Table 25. Herbicide concentrations in ambient air samples

<u>Sample Number</u>	<u>Filter Number^b</u>	Average air Concentration ^a (ng/m ³)	
		<u>2,4-D</u>	<u>2,4,5-T</u>
14820	P-20 (filter) ^c	5.81	27.8
14821	P-20 (top 2 PUFs) ^c	<2.53 ^d	<0.76 ^d
14822	P-20 (bottom PUF) ^c	<2.53	4.29
--	P-20 total	<10.87 ^c	<32.85 ^c
17949	H-11 ^e	1.55	2.97
17962	P-745 (filter) ^f	<2.54	0.51
17963	P-745 (top 2 PUFs) ^f	5.84	12.2
17964	P-745 (bottom PUF) ^f	<2.54	<0.25
--	P-745 total	<10.83 ^f	<12.96 ^f
17966	H-13 ^g	<1.63	1.80

a. See Appendix T, Exhibit 5, for ITAS data sheets.

b. Only these filters were selected for herbicide analysis. See Table 10 for detail sampling data.

c. Onsite monitoring during soil drying activities on December-11 and -12. For total concentration, the three sets of data are summed.

d. < values indicate that no constituent was detected; the detection limit value is shown.

e. Downwind monitoring during test burn on December 8.

f. Onsite monitoring during test burn on December 15. For total concentration, the three sets of data are summed.

g. Downwind monitoring during test burn on December 15.

SECTION VI

EVALUATION AND DISCUSSION

This section summarizes the results of the test verification burns at NCBC and discusses the full-scale process performance. The ability of the process to produce a treated soil that will meet EPA petitioning criteria (40 CFR 260.22) to exclude the soil as a hazardous waste (i.e., delisting) is addressed. Significant problems encountered during the test verification burns are identified and discussed in terms of their potential impact on performance during full-scale soil treatment and restoration at the NCBC site.

A. SOIL TREATMENT

The effectiveness of the soil treatment is discussed in four parts: dioxin/furan reduction, organic compound reduction, inorganics, and hazardous waste assessment.

1. Dioxins/Furan Reduction

The analytical results showed that all test runs satisfied the project goal that the treated soil PCDD/PCDF congener sum (tetra, penta, and hexa) be less than 1.0 ppb (Table 26). The level of treatment was achieved by nearly two orders of magnitude. Sample AD-3 from Test Burn 3 produced the highest sum at 0.021 ppb in which TCDF was detected at 0.016 ppb and represented the most significant contributor. Sample AD-1 from Test Burn 1 produced the lowest sum at 0.009 ppb, but this was totally dependent upon DLVs because none of these congeners was detected in the sample. Comparison of these two data points shows consistency with the operating conditions of the kiln. Test Burn 1 operated at a higher average kiln temperature and lower average soil feed rate (i.e., longer soil residence time), each of which represents increased thermal desorption of the dioxins and furans from the soil being processed compared to runs at low temperature and higher

Table 26. Summary of treated soil PCDD/PCDF congener sums and kiln operating conditions

<u>Test Burn</u>	<u>Average Kiln Temperature^a (°F)</u>	<u>Average Soil Feed rate^a (tons/hr)</u>	<u>Congener Sum^b (ppb)</u>
1	1645	2.82	<0.0091 ^c
2	1377	3.64	<0.0200 ^d
3	1552	3.71	<0.0214 ^d
5	1485	5.22	<0.0106 ^d
6	1355	6.31	<0.0170 ^d

a. Operating data from Table 6.

b. Sum of total tetra, penta, and hexa congeners of PCDD and PCDF. Data from Tables 13 for Samples AD-1 through AD-6.

c. None of the congeners were detected in the treated soil sample AD-1. Sum of analytical DLVs is shown and thus represents a conservative value.

d. Total TCDF was detected in Samples AD-2, -3, -5, and -6. Sum represents TCDF detected concentration and analytical DLVs for other five congeners not detected and represents a conservative value.

feed rates. When congener sums from all five test burns are compared with the kiln operating conditions, clearly defined trends are not observed. Masking of expected trends is largely due to the general condition that the congeners were not detected and DLVs were extensively used to report an upper bound.

Comparison of treated soil and feedstock 2,3,7,8-TCDD and total TCDD concentration results from Table 13 shows that significant removal of dioxin concentrations in the soil residue occurs by the MWP-2000 incinerator process. Soil-to-ash removal efficiencies (SAREs) of at least four nines were achieved for both species in all five test burns (Table 27). The calculated soil SAREs ranged between 99.9921 and 99.9966 percent for 2,3,7,8-TCDD and between 99.9952 and 99.9984 percent for total TCDD. In all cases these represent lower bounds because neither of the species were detected in any of the treated soil samples and the DLVs were used in the calculations. Even though HRMS was used in the analysis of the treated soil samples, the magnitudes of the detection levels and the relatively low concentrations in the feedstock samples (32-61 ppb 2,3,7,8-TCDD) have limited the demonstration of how well the incinerator process can remove dioxins from the soil.

Comparison of treated soil and feedstock 2,3,7,8-TCDF and total TCDF results from Table 13 shows that substantial removal of furan concentrations in the soil residue occurs by the MWP-2000 incinerator process. Calculated SAREs ranged between 96.5455 and 98.5333 percent for 2,3,7,8-TCDF and between 97.2413 and 99.8000 percent for total TCDF (Table 27). Because treated soil DLVs were used in the SARE calculations for the high value of the range for each species, the range is actually higher. Upon first examination, the results indicate considerably poorer response in the thermal desorption process for furan removal in the kiln; this is not to be expected. There are two reasons to explain the difference. First, the chromatogram signal bandwidth used in the furan analysis of Samples AD-2, -3, -5, and -6, which showed detection of 2,3,7,8-TCDF and total TCDF, is broader than would normally be used and thus appears to introduce a procedural bias. It should be noted that the concentrations detected are fairly close to the DLV for Sample AD-1. Also, the furan concentrations in the feedstock samples

Table 27. Summary of calculated treated soil TCDF/TCDF soil-to-ash removal efficiencies and kill, operating conditions

Test Burn	Average Kill Temperature (°F)	Average Soil feed rate (tons/hr)	Calculated Soil-to-Ash Removal Efficiency (SARE) ^b			
			Total TCDF ^c	2.3, 2.8, 1 (mg)	Total TCDF ^c	2.3, 2.8, 1 (mg)
1	1645	2.82	>99.9984 ^d	>99.9997 ^d	>99.8000 ^d	>96.5333 ^d
2	1377	3.64	>99.9912	>99.9921	97.2613	96.9375
3	1552	3.71	>99.9976	>99.9953	97.2413	97.3000 ^e
5	1485	5.22	>99.9952	>99.9948	99.9648	98.5000
6	1355	6.31	>99.9959	>99.9961	>99.1000	96.5455

a. Operating data from Table 6.

b. Calculation: SARE (percent) = $\frac{C_{FS} - C_{TS}}{C_{FS}} \times 100$ where C_{FS} is the concentration from the feedstock sample and C_{TS} is the concentration from the treated soil sample.

c. Based on concentration or DV data in Tables 13. Calculation.

d. Lower bound for SARE shown because species was not detected in the treated soil sample; the DV was used in the calculation.

e. Upper bound for RF shown because species was not detected by LRMS in the feedstock sample; however, the species was detected by HRMS in the treated soil sample. The feedstock DV was used in the calculation.

(total TCDF ranged from 0.45 to 1.2 ppb) were quite low compared to the TCDD concentrations in the same samples. Therefore, in this process the dioxin results should be used as the general indicator on the cleanup capability of dioxin/furan contaminated soil.

2. Organic Compound Reduction

Evaluation of organic compound removal performance is limited to reduction of HO constituents (2,4-D, 2,4,5-T, and 2,4,5-trichlorophenol) and three PAHs [fluoranthene, benzo(b)fluoranthene, and benzo(a)pyrene] because of their detection in the feedstock samples for one or more test burns. Of these, 2,4-D and 2,4,5-T had the highest concentrations and provide the best indication of the process performance for treated soil.

Comparison of treated soil and feedstock 2,4-D and 2,4,5-T concentration results from Table 14 shows that significant removal of the herbicide concentrations in the soil residue occurs by the MWP-2000 incinerator process. Calculated SAREs of five nines for two test burns and four nines for the remaining three test burns were achieved for 2,4,5-T (Table 28). The SAREs ranged between 99.9957 and 99.9998 percent. In all cases these represent lower bounds because 2,4,5-T was not detected in any of the treated soil samples and the DLVs were used in the calculations. Test Burn 6 represents a very significant data point because it achieved the highest indicated RE (99.9998 percent) under the most severe operating conditions: lowest average kiln temperature (1355°F) and highest average soil feed rate (6.31 tons/hr). Because all treated soil samples had an identical DLV, the variability of the SARE was due to the different feedstock concentrations of 2,4,5-T, which was maximum at 840 ppm for Test Burn 6. These results suggest that the MWP-2000 incinerator process is capable of achieving at least SAREs of six nines for this herbicide.

The 2,4-D herbicide SARE results were lower with a range between 99.9130 and 99.9994 percent (Table 28). The primary difference for the lower range was due to a DLV (same for all five samples) that was 10 times larger than the DLV for the 2,4,5-T analyses. Some feedstock

Table 28. Summary of calculated treated soil 2,4-D and 2,4,5-T soil-to-ash removal efficiencies

<u>Test Burn</u>	<u>Calculated Soil-to-Ash Removal Efficiency (SARE)^a (percent)</u>	<u>2,4-D^b</u>	<u>2,4,5-T^b</u>
1	>99.9643 ^c	>99.9980 ^c	
2	>99.9994	>99.9996	
3	>99.9833	>99.9991	
5	>99.9130	>99.9957	
6	>99.9950	>99.9998	

a. Calculation: SARE (percent) = $\frac{C_{FS} - C_{TS}}{C_{FS}} \times 100$ where C_{FS} is the concentration from the feedstock sample and C_{TS} is the concentration from the treated soil sample.

b. Based on concentration data in Tables 14.

c. Lower bound for SARE shown because species was not detected in the treated soil sample; the DLV was used in the calculation.

concentrations were also lower. Because of these data limitations, the 2,4,5-T results should be used as the general indicator on the cleanup capability of HO herbicide contaminated soil by this process.

Cleanup of 2,4,5-trichlorophenol occurred; however, the reduction evaluation is limited because of low initial concentrations (ranged between 1.6 and 8.8 ppm) and high DLVs (1.6 ppm in four of the treated soil samples). The best demonstrated performance for 2,4,5-trichlorophenol reduction was for Test Burn 5 in which the DLV for the treated soil sample (AD-5) was 0.21 ppm; whereas, the concentration in the feedstock sample (FS-5) was 8.8 ppm.

Although only found in the ppb range in the feedstock samples, some reduction in concentrations for the three PAHs was observed. For example, fluoranthene in Test Burn 2 was shown to reduce from 110 ppb in the feedstock sample (maximum for the PAHs) to a detectable concentration of 2.7 ppb in the treated soil sample.

3. Inorganics

The element averages and ranges for the metals analyzed for in the five feedstock and five treated soil samples are shown in Table 29 for comparison. Within the variability of individual analyses, no observed differences of any significance occur. Barium, which has the highest concentration, does show a slight reduction (20 percent) in the treated soil.

4. Hazardous Waste Assessment

The goal of any waste treatment process technology is to have the treated waste no longer considered as hazardous. A petition mechanism (to EPA Headquarters) is described in 40 CFR 260.20 and 40 CFR 260.22, which allows persons to demonstrate that a specific waste from a particular site or generating facility should not be regulated as a hazardous waste under 40 CFR 261. To be excluded, petitioners must show that the waste does not meet any of the listed criteria and also must demonstrate that the waste

Table 29. Comparison of average inorganic concentrations in feedstock and treated soil for test burns

<u>Element</u>	Feedstock ^a (ppm)		Treated Soil ^a (ppm)	
	<u>Average</u>	<u>Range</u>	<u>Average</u>	<u>Range</u>
Arsenic	6.8	4.1-9.8	3.5	2.7-3.9
Barium	36	23-61	28	12-48
Cadmium	0.23 ^b	--	0.17 ^b	--
Chromium	7.1	5.7-8.4	5.7	4.1-7.6
Lead	8.5	6.6-10.0	4.5	3.4-6.2
Mercury	0.06 ^c	0.02-0.12 ^c	0.03 ^d	--
Nickel	1.9 ^e	1.7-2.2 ^e	2.2 ^f	1.8-2.6 ^f
Selenium	0.20 ^d	--	0.20 ^e	0.20
Silver	<0.02 ^g	--	<0.02 ^g	--

a. Based on data from Table 15.

b. Based on single data points from Test Burn 6. Not detected in samples from other four test burns.

c. Based on detected concentrations in three of five samples.

d. Based on single data point from Test Burn 3. Not detected in samples from other four test burns.

e. Based on detected concentrations in two of five samples.

f. Based on detected concentrations in four of five samples.

g. Not detected in any of the samples. DLV shown.

does not exhibit any of the hazardous waste characteristics and does not contain any other toxicants at hazardous levels (Reference 23). This regulatory process is called "delisting". The delisting process for the NCBC project was initiated with EPA in January 1986 and is ongoing at the time of this writing. Section I.B.7 summarizes this process up to the time of the verification test burns.

AFESC and EG&G Idaho decided that the ability of the ENSCO MWP-2000 incinerator system technology to demonstrate the NCBC treated soil delistability would be assessed within the scope of the planned sample analysis as modified by EPA/OSW guidance (Appendix E, Exhibits 4 and 6). This is discussed in Section III, namely PCDDs and PCDFs, selected organics and inorganics, HO constituents 2,4-D and 2,4,5-T, cyanide/sulfide, and EP toxicity specified in 40 CFR 261.24. The PCDDs and PCDFs are listed as acutely hazardous (F028) in 40 CFR 261.31. Many of the organic and inorganic compounds are both listed as hazardous in 40 CFR 261.33 and are shown on the Priority Pollutant List (PPL). The delisting process with OSW would continue in parallel with the full-scale soil restoration at the NCBC site. Within the stated limitation, the following assessments are made in relation to the criteria:

a. Hazardous Waste Characteristics

(1) Ignitability. The objective of examining the ignitability characteristic is to identify substances that either present fire hazards under routine storage, disposal, and transportation, or can contribute to a fire once started. The treated soil does not possess either of these characteristics because it can neither start nor sustain combustion.

(2) Corrosivity. The corrosivity characteristic, defined in 40 CFR 261.22, is intended to identify substances that might pose a hazard to human health or the environment because of their ability to:

- Mobilize toxic metals if discharge in a landfill

- Corrode handling, storage, transportation, and management equipment
- Destroy human or animal tissue in the event of inadvertent contact.

In 40 CFR 261.22, EPA specifies two properties that define a corrosive substance: pH and corrosivity toward Type SAE 1020 steel. A substance is defined as corrosive if:

- It is aqueous and has a pH ≤ 2 or ≥ 12.5 .
- It is a liquid and corrodes steel (SAE 1020) at a rate of >6.35 mm/yr at a test temperature of 131°F.

The methods to determine these properties, also specified in 40 CFR 261.22, are clearly oriented toward aqueous or liquid substances and, therefore, do not apply to treated soil. As shown in Table 16, treated soil samples from the five test burns were analyzed by mixing equal portions of soil and distilled, deionized water to form a slurry. The slurry was tested for pH, which was shown to range between 10.74 and 11.99. The pH requirement has been demonstrated nevertheless.

(3) Reactivity. EPA Regulation 40 CFR 261.23 defines reactive substances as those that have any of the following properties:

- Readily undergo violent chemical change
- React violently or form potential explosive mixtures with water
- Generate toxic fumes when mixed with water or, in the case of cyanide or sulfide-bearing wastes, when exposed to mild acidic or basic conditions
- Explode when subjected to a strong initiating force

- Explode at normal temperatures and pressures
- Fit within the U.S. Department of Transportation's forbidden explosives, Class A explosives, or Class B explosives classifications.

Because of the extremely inert quality of the treated soil, it does not meet any of these criteria.

Regarding the possibility of cyanide fumes, analysis of three treated soil samples did show detectable amounts of cyanide in the range 0.70-1.0 ppm, which was just above the DLV of 0.50 ppm. However, these three samples were further analyzed by the EP Toxicity test procedures and cyanide was not detected (DLV of 0.01 µg/L). The possibility of sulfide fumes is very small because analysis results for the treated soil samples show low concentrations of sulfide (34-110 ppm, from Table 16) and the basic pH of the treated soil. Based on the above, the treated soil is not a reactive substance.

(4) Extraction Procedure Toxicity. The extraction procedure (EP) is designed to simulate the leaching a substance will undergo if disposed in a sanitary landfill. It is a laboratory test in which a representative sample of waste (100 grams) is extracted with distilled water maintained at a pH of 5, using acetic acid. The EP extract is then analyzed to determine if any of the thresholds established for eight elements (arsenic, barium, cadmium, chromium, lead, mercury, selenium, silver), four pesticides (Endrin^R, Lindane^R, Methoxychlor^R, Toxaphene^R), and two herbicides [2,4,5-TP (Silvex^R), 2,4-D] have been exceeded. If the EP extract contains any one of the above substances in an amount equal to or exceeding the levels specified in 40 CFR 261.24, the substance possesses the characteristic of EP toxicity and therefore is a hazardous waste.

The EP toxicity test was not actually performed on the treated soil samples because the concentrations of the listed constituents were so low. The measured residual soil concentrations were used to calculate the maximum (worst case) concentration for each contaminant that

could be present in the extract resulting from subjecting the treated soil to the EP toxicity test. These calculated extract concentrations were compared with the criteria levels specified in 40 CFR 261.24 to determine if the treated soil would be classified as hazardous based on the EP toxicity characteristic. Table 30 summarizes the measured concentration (average of results for treated soil samples for the five tests), calculated maximum concentrations, and EPA criteria. The calculated concentrations are at least an order of magnitude below the criteria in all cases.

The herbicide, 2,4,5-TP Silvex^R (2,4,5-trichlorophenoxypropionic acid) was not tested, but the HO constituent 2,4,5-T (2,4,5-trichlorophenoxyacetic acid) was tested and, because of similar chemical structure, can be used as an upper bound for 2,4,5-TP in this assessment. Results from the five treated soil samples showed no detectable 2,4,5-T with a DLV of 0.002 ppm. As indicated in Table 30, the maximum concentration in an EP extract based on this DLV is insignificant compared to the limit.

Endrin, lindane (gamma-BHC), and methoxychlor were not included in the sample analysis plan because earlier analysis of soil feedstock for the pilot-scale thermal desorption/ultraviolet photolysis process testing at NCBC in 1985 showed none of them was detected (Reference 17). DLVs of 0.07, 0.03, and 0.67 ppm are indicated in the referenced report. If these values are assumed as DLVs for the treated soil from the MWP-2000 incinerator testing, the following maximum concentrations in the EP extract are calculated following the example in Table 30: 0.0035, 0.0015, and 0.034 mg/L for Endrin^R, Lindane^R, and Methoxychlor^R, respectively. Each is well below the limit.

b. Acutely Hazardous Waste Assessment

The data presented in this report have established that PCDD/PCDF (waste category F028) can be effectively removed from the tested soil (to less than 1 ppb, 2,3,7,8-TCDD and total tetra-, penta-, and hexa-isomers) by this technology at certain operating conditions. No other compounds were detected in the feedstock that are listed as acutely hazardous in 40 CFR 261.33.

Table 30. Concentrations of elements in treated soil EP extract assuming complete extraction

<u>Element</u>	<u>Concentrations in Treated Soil^a (mg/kg)</u>	<u>Maximum Concentration in EP Extract^b (mg/L)</u>	<u>EPA Threshold Limitation^c (mg/L)</u>
Arsenic	3.5	0.175	5.0
Barium	28	1.40	100.0
Cadmium	0.17	0.0085	2.0
Chromium	5.7	0.285	5.0
Lead	4.5	0.225	5.0
Mercury	0.03	0.0015	0.2
Selenium	0.20	0.010	1.0
Silver	<0.02 ^d	<0.0010	5.0
Endrin	NA ^e	--	0.02
Lindane	NA ^e	--	0.4
Methoxychlor	NA ^e	--	10.0
Toxaphene	<0.208 ^d	<0.010	0.5
2,4-D	<0.02 ^d	<0.0010	10.0
2,4,5-TP (Silvex)	<0.002 ^f	<0.0001	1.0

a. See Table 29 for average inorganic concentrations and Table 14 for organic concentrations.

b. Sample calculation for arsenic in EP extract assuming complete extraction.

$$100 \text{ gram sample} \times 3.5 \text{ mg/kg} \times \frac{\text{kg}}{1000 \text{ g}} = 0.35 \text{ mg}$$

0.35 mg of arsenic dissolved in 2 L of solution results in a concentration of:

$$\frac{0.35 \text{ mg}}{2 \text{ L}} = 0.175 \text{ mg/L}$$

Table 30. (continued)

- c. Limits from 40 CFR 261.24.
- d. Not detected in any of the five samples. DLV shown.
- e. NA means not analyzed. Previous sample analyses performed with the pilot-scale tests (References 17 and 18) showed these pesticides were not detected in the feedstock.
- f. DLV for 2,4,5-T shown.

In the Federal Register of November 7, 1986 (Reference 22), EPA has proposed the following criteria for landfill disposal of materials contaminated with dioxins:

- Contamination at levels ≥ 1 ppb dioxins requires treatment
- Treated material <1 ppb requires a Toxicity Characteristic Leaching Procedure (TCLP) analysis (Appendix J to 40 CFR 268)
- Material meeting these criteria can be disposed of in a Class C landfill. Alternatively, the owner of the waste may submit a delisting petition to EPA that requires the waste be removed from the list of hazardous wastes. The standards for granting that request are much more stringent than the aforementioned landfull standards.

The MWP-2000 incinerator testing at NCBC has demonstrated that the first criterion can be readily met after soil treatment. At the time of writing this document, TCLP remains to be done and represents a limitation on showing that the final criterion can be met.

c. Hazardous Constituents Review

The sampling analysis plan submitted (Appendix E, Exhibit 5) and approved by EPA/OSW (Appendix E, Exhibit 6) represents the selection of constituents to investigate following a thorough screening process. Of the selected list of organics, only 2,4,5-T (listed as a toxic hazardous waste in 40 CFR 261.33) and 2,4,5-trichlorophenol and 2,4-D (listed in Appendix VIII of 40 CFR 261 were detected in the feedstock at concentrations in excess of 1 ppm. Treated soil sample results showed none of these organics being detected. The herbicide DLVs were well below 1 ppm. Although four of the five DLVs for the 2,4,5-trichlorophenol were 1.6 ppm, one sample had a DLV at 0.21 ppm suggesting a more likely condition below 1 ppm for that organic in the residue soil.

Of the inorganics investigated and detected at concentrations above 1 ppm, five are listed in 40 CFR 261, Appendix VIII (barium lead, chromium, arsenic, and nickel); however, the average concentrations were low. As evaluated by the EP toxicity calculation (Table 30), these concentrations of inorganics are low and should be considered not hazardous. Were it not for the presence of HO constituents in the soil from the earlier spills, the in situ soil would be considered nonhazardous.

d. VHS Model Analysis

The vertical horizontal spread (VHS) equation is a non-site specific groundwater transport model used by EPA as a prime consideration used in the delisting process. The equation attempts to model the fate of a given contaminant in a drinking water aquifer as it moves off of a hazardous waste site towards a drinking water well. EPA described and promulgated this model on November 27, 1987 (50 Federal Register 48896 - 48915, Reference 24).

The model uses the following expression to determine a concentration of the contaminant in drinking water arbitrarily set 500 feet down-gradient from a waste pit.

$$C_y = C_0 \operatorname{erf} \left\{ \left(-\frac{Y'}{4Y} \right)^{0.5} \right\} \operatorname{erf} \left\{ \frac{X}{4(\alpha_t Y)^{0.5}} \right\}$$

where

C_y = Predicted groundwater concentration at a hypothetical receptor well located a distance Y down gradient (ppm)

C_0 = Leachate concentration obtained from EP Toxicity data or the Organic Leachate Model (ppm)

Y' = Width of hypothetical trench, fixed at 12.2 meters

Y = Distance to the receptor well, fixed at 152.4 meters

a_t - Transverse dispersivity, fixed at 2 meters

X - Length of the hypothetical trench, in meters, calculated from the waste volume assuming a trench of 12.2 meters (40 feet) wide and 2.4 meters (8 feet) deep.

The only variables in the equation that are not previously fixed by EPA are X, the length of the hypothetical trench, and the two concentrations C_y and C_0 . If the volume of waste exceeds 6,116 cubic meters (8,000 cubic yards), where X would equal 206 meters, then the second error function in the equation approaches unity.

Normally, C_0 is determined through analysis using the EP Toxicity Test or the Oily Waste EP Toxicity Test. For organics, however, EPA considered those tests inaccurate, therefore, at the time that the VH model was promulgated, EPA also proposed an empirical model in 50 FR 48943-43967 (Reference 32) for predicting C_0 , the concentration of an organic in leachate as it enters the aquifer. Based upon that proposed equation, EG&G Idaho ran the two models and determined that if the soil was processed and achieved a cleanup standard of less than 0.1 ppb, then the incinerator residue could easily be delisted (Appendix E, Exhibit 7). Those calculations assumed a solubility of dioxin in water of 100 ppt and a pseudo-drinking water standard of 0.2 ppq (a ppq is a part per quadrillion or 10^{-15}).

Because there was no maximum concentration level for 2,3,7,8-TCDD in either the National Primary Drinking Water Standard or the National Secondary Drinking Water Standard, EPA adopted a pseudo-drinking water standard based upon a cancer risk specific dose estimate of 6.4×10^{-12} mg/kg body weight-day. (Reference 33). That risk estimate was based upon a plausible upper-bound increased cancer risk of one in a million (10^{-6}) when exposed to the carcinogen at the dose rate for a lifetime. EPA then assumed that a 70 kg person residing near the waste site consumed 2 liters of water per day from a potentially contaminated drinking water well. This resulted in a pseudo-drinking water standard of 0.2 ppq (i.e., 2×10^{-4} ppt). It is important to note that this pseudo-drinking

water standard is more than two orders of magnitude below the best available analytical detection limits of 0.035 ppt observed for clean tap water (see Table 22).

On July 29, 1986, EPA proposed a revised OLM equation in 51 R 27061 - 27064 (Reference 34). That model, which became final on November 13, 1986 in 51 FR 41082 - 41100 (Reference 35), is given by:

$$C_0 = 0.00221 C_w^{0.678} S^{0.373}$$

where C_0 = leachate entering the aquifer, mg/l

C_w = concentration of organic in the waste residue, mg/l

S = the solubility of the organic, mg/l

By including the revised OLM equation for C_0 , the VHS equation becomes:

$$C_y = C_w^{0.678} S^{0.373} (0.00221) \operatorname{erf} \left\{ \left[\frac{Y'}{4Y} \right]^{0.5} \right\} \operatorname{erf} \left\{ \frac{X}{4(\alpha_t y)^{0.5}} \right\}$$

Simplification is achieved by substituting the fixed values specified by EPA.

$$C_y = C_w^{0.678} S^{0.373} (0.00221) \operatorname{erf} (.141) \operatorname{erf} (2.95)$$

Rearranging and evaluating the error function terms, the VHS equation becomes:

$$C_y = C_w^{0.678} S^{0.373} (0.0003344)$$

It is interesting to note that the only volume dependent term in the expanded VHS equation is in the second error function term. From this, it can be seen that the larger the waste volume, the lower the allowed concentration of organic contaminant in the waste. Furthermore, if the waste volume exceeds 6116 cubic meters (8000 cubic yards), then the second error function term approaches unity. This means that if the drinking water standard is used for C_y and if the waste volume exceeds 6116 cubic meters, then the cleanup standard remains fixed and independent of waste volume.

In 1986, both EG&G and EPA used 100 ppt for the solubility and 0.224 ppq for the compliance point concentration, C_y . This resulted in an allowed waste concentration of 0.116 ppt. Because the analytical detection limits of the incinerator residue were projected to be approximately 5 ppt, the delistability of the incinerator residue became uncertain.

Closer examination of EPA's use of the OLM equation revealed that the 100 ppt solubility term, S, was based upon pure 2,3,7,8-TCDD in pure deionized and distilled water. Additional research by the Monsanto Company revealed that the actual solubility of 2,3,7,8-TCDD in soil was 7.96×10^{-6} ppm (7.96 ppt), or two orders of magnitude lower than the previously used solubility (Reference 36). This correction to the solubility was submitted to EPA on February 25, 1987 (Appendix E, Exhibit 8). Using this solubility and a pseudo-drinking water standard of 0.224 ppq (Reference 33), a delisting criteria, C_w , of 0.499 ppt of 2,3,7,8-TCDD can be obtained in the soil. This level, however, is still below the best achievable detection limit using HRGC/HRMS. Fortunately, EPA recognized this dilemma when they promulgated the OLM equation in 51 FR 41082 - 41100 (Reference 35); they stated: "Where hazardous constituents in a waste are determined to be non-detectable using appropriate analytical methods, the Agency will, as a matter of policy, not regulate the waste as hazardous." This simply meant that the waste analysis had to show non-detectable concentrations of 2,3,7,8-TCDD using high resolution GCMS techniques in order to potentially obtain delisting. As shown in Table 13, neither 2,3,7,8-TCDD nor total TCDD were detected in the incinerator ash, thus delisting appeared probable.

By using the maximum observed detection limit given for the incinerator residue in Table 13 and a solubility of 7.96×10^{-6} ppm, the concentration of 2,3,7,8-TCDD projected at the compliance point (i.e., the postulated drinking water well), C_y , is 8.2×10^{-8} ppm or 0.082 ppt. This projected concentration is nearly the same as the best available analytical detection limit observed for clean tap water, 0.035 ppt (see Table 22).

e. Concluding Remarks

The following conclusions can be made relating to the MWP-2000 incinerator system process producing a delistable waste from the HO-contaminated NCBC soil. Because the treated soil is not corrosive, ignitable, or reactive and because it passes the requirements for the EP toxicity test, the requirements of 40 CFR 261.21-261.24 can be satisfied. The acute hazardousness of the contaminated soil can be reduced to concentrations of dioxins that are less than 1 ppb so that the residue could be disposed in an EPA approved landfill. The cost of land disposal, however, would be substantial. The concentrations of the HO-related organics detected in the feedstock above 1 ppm were removed to nondetectable levels well below 1 ppm in the treated soil. Inorganics listed in Appendix VIII of 40 CFR 261 were found at sufficiently low concentrations that the EP toxicity results had substantial margins. If EPA denies delisting, then TCLP analysis on the ash must be performed so that the land disposal requirements in 51 FR 40572 - 40654 (Reference 22) can be met.

B. INCINERATOR PERFORMANCE

EPA requires that incinerators burning hazardous waste must meet three performance standards. As specified in 40 CFR 264.343, these standards relate to: (1) destruction and removal efficiency (DRE) of each principal organic hazardous constituent (POHC) for wastes designated as F020, F021, F022, F023, F026, or F027, (2) a limit on HCl emissions from the stack, and (3) a limit on particulate matter emitted from the stack. These requirements were specified in the RD&D permit (Volume V) and are shown in Section IV.C.3.a. The following discussion in this subsection presents an evaluation of the MWP-2000 incinerator system performance regarding these performance standards.

1. Destruction and Removal Efficiency

The DRE calculations are based on the mass feed rate of a contaminant compound into the incinerator and the mass emission rate of that compound from the stack. More specifically, the expression is:

$$\text{DRE (percent)} = \frac{W_{in} - W_{out}}{W_{in}} \times 100$$

where:

W_{in} = mass feed rate one POHC in the waste stream feeding the incinerator

W_{out} = Mass emission rate of the same POHC present in the exhaust emissions prior to release to the atmosphere.

The calculated results for 2,3,7,8-TCDD are presented in Table 31 to compare with the permit requirements. The calculated DREs range from 99.9968 to 99.9985 percent, which is less than the 99.9999 percent required in the permit. These calculated values represent lower bounds because 2,3,7,8-TCDD was not detected in the MM5 samples for any of the test burns and the respective DLVs were used in each calculation. The inability to demonstrate the required six nines is due to low concentration of 2,3,7,8-TCDD in the feedstock samples relative to the detectability in the MM5 samples. This is supported by Test Burn 6, which showed the highest DRE, but the most stringent kiln and secondary combustion chamber (SCC) conditions (e.g., maximum soil feed rate, minimum kiln temperature, minimum SCC temperature). A surrogate of greater feed concentration is needed to demonstrate the six nines requirement.

Table 31. Destruction and removal efficiency calculational results (2.3.7.8-TCDD) for Map-2000 Incinerator System NBC verification test burns

Parameter	Test Run				
	1	2	3	5	6
Soil feed rate (tcps/hr) (10 g/hr)	2.82 2.558	3.64 3.302	3.71 3.366	5.22 4.735	6.31 5.724
Feed concentration (ppb) ^b	32	56	36	50	45.8
2.3.7.8-TCDD feed rate (10 ⁻² g/hr)	8.186	18.491	12.118	23.677	26.216
Stack flow rate (5 m ³ /hr) ^c	12.029	13.386	13.048	12.380	14.592
Stack concentration (ng/m ³) ^d	<0.22 ^e	<0.26 ^e	<0.23 ^e	<0.32 ^e	<0.27 ^e
2.3.7.8-TCDD emissions rate (10 ⁻⁶ g/hr)	<2.6 ^f	<3.5 ^f	<3.0 ^f	<4.0 ^f	<3.9 ^f
DRE (percent) ^g	<99.9968 ^h	<99.9981 ^h	<99.9975 ^h	<99.9983 ^h	<99.9985 ^h

- a. Feed rate data from Table 6.
- b. Feedstock concentration data from Table 13.
- c. Based on stack gas flow rate data from Table 9 converted to metric units.
- d. Stack gas concentration data from Table 17.
- e. Not detected. Detection limit value (DLV) shown.
- f. Because DLV used in calculation, emissions rate is less than shown.
- g. Expression:

$$\text{DRE (percent)} = \frac{V_{\text{in}} - V_{\text{out}}}{V_{\text{in}}} \times 100$$

where

$$V_{\text{in}} = 2.3.7.8-\text{TCDD feed rate (g/hr)}$$

$$V_{\text{out}} = 2.3.7.8-\text{TCDD emissions rate (g/hr)}$$

- h. DRE higher than shown because DLVs were used for emissions data.

Destruction and removal efficiencies were also calculated for the two primary POHCs in the contaminated soil feedstock, 2,4-D and 2,4,5-T (Tables 32 and 33). The calculated DREs range from 99.9736 to 99.9999 percent for 2,4-D and from 99.9968 to 99.9999 percent for 2,4,5-T. Only one data set (Test Burn 5 for 2,4-D) failed to meet the 99.99 percent required for POHCs in 40 CFR 264.343(a)(1). Because neither of the herbicides was detected in the MM5 samples, the DLVs were used in the DRE calculations giving a lower bound value. The incinerator system capability is more logically demonstrated by the fact that DREs for 2,4-D from Test Burn 2 and for 2,4,5-T from Test Burns 2 and 6 achieved performance of six nines. Test Burn 6 was run at the most severe operating conditions among the five test burns. The DREs for the other test burns are low only because of low contaminant concentration in soil feedstock relative to the HRMS detection capability with the MM5 samples. However, the herbicides have provided a significant indication of the incinerator system capability compared to the 2,3,7,8-TCDD results.

Even though a DRE of 99.9999 percent was demonstrated for two of the tests on 2,4,5-T and for one test on 2,4-D, EPA would not permit the results of these tests to be used in lieu of a formal RCRA trial burn. As stated in Reference 37, EPA requires that a DRE of 99.9999 percent be demonstrated on three separate tests using a POHC that is more difficult to destroy than the POHC to be processed during normal operations. Although the 2,4,5-T is more difficult to destroy than 2,3,7,8-TCDD, the 2,4-D is not. Therefore, the Verification Test Burns were not able to demonstrate compliance with the RCRA 99.9999 percent DRE requirement (the reader should keep in mind, however, that demonstration of 99.9999 percent DRE was not within the scope of the original test plan).

2. Hydrogen Chloride Emissions

The chloride concentrations in the five test burn MM5 composite samples ranged between 0.06 and 0.29 $\mu\text{g}/\text{m}^3$, with the maximum

Table 32. Destruction and removal efficiency calculation results (2.4-D) for MW-2000 incinerator system NCBC verification test burns

Parameter	Test Burn				
	1	2	3	5	6
Soil feed rate (tons/hr) ^a (10 ⁻³ g/hr)	2.82	3.64	3.71	5.22	6.31
Feed concentration (ppm) ^b	2.558	3.302	3.366	4.735	5.724
2.4-D feed rate (g/hr)	56	3.300	120	23	400
Stack flow rate (5 m ³ /hr) ^c	143.26	10,896.90	403.87	108.91	2,289.69
Stack concentration (ng/m ³) ^d	<10 ^e	13.386	13.048	<2.380	14.592
2.4-D emissions rate (10 ⁻³ g/hr)	<8.5 ^f	<1.050 ^e	<1.240 ^e	<2.320 ^e	<980 ^e
DRE (percent) ^g	<99.994 ^h	<99.999 ^h	<95.9960 ^h	<99.9736 ^h	<99.9994 ^h

- j. Feed rate data from Table 6.
- b. Feedstock concentration data from Table 14.
- c. Based on stack gas flow rate data from Table 9 converted to metric units.
- d. Stack gas concentration data from Table 18.
- e. Not detected. Detection limit value (DLV) shown.
- f. Because DLV used in calculation, emissions rate is less than shown.
- g. Expression:

$$\text{DRE (percent)} = \frac{W_{\text{out}} - W_{\text{in}}}{W_{\text{in}}} \times 100$$

where

$$W_{\text{in}} = 2.4-\text{D feed rate (g/hr)}$$

$$W_{\text{out}} = 2.4-\text{D emissions rate (g/hr)}.$$

- h. DRE higher than shown because DLVs were used for emissions data.

Table 33. Destruction and removal efficiency calculation results (2.4.5-T) for MWP-2000 incinerator system
NCBC verification test burns

Parameter	1	2	3	5	6
Soil feed rate (tops/hr) (10 ⁶ g/hr)	2.82 2.550	3.64 3.302	3.71 3.366	5.22 4.735	6.31 5.724
Feed concentration (ppt) ^b	100	510	220	47	840
2.4.5-T feed rate (10 ⁻² g/hr)	255	1,684	740	222	4,808
Stack flow rate (5 m ³ /hr) ^c	12,029	13,386	13,048	12,360	14,592
Stack concentration (ng/m ³) ^d	<212 ^e	<104 ^e	<724 ^e	<580 ^e	<293 ^e
2.4.5-T emissions rate (10 ⁻³ g/hr) ^g	<2.5 ^f	<1.4 ^f	<9.4 ^f	<7.2 ^f	<4.3 ^f
DRE (percent) ^g	<99.9990 ^h	<99.9999 ^h	<99.9988 ^h	<99.9968 ^h	<99.9999 ^h

- a. Feed rate data from Table 6.
- b. Feedstock concentration data from Tables 14.
- c. Based on stack gas flow rate data from Table 9 converted to metric units.
- d. Stack gas concentration data from Table 18.
- e. Not detected. Detection limit value (DLV) shown.
- f. Because DLV used in calculation, emissions rate is less than shown.
- g. Expression:

$$\text{DRE (percent)} = \frac{W_{\text{in}} - W_{\text{out}}}{W_{\text{in}}} \times 100$$

where

$$W_{\text{in}} = 2.4.5-\text{T feed rate (g/hr)}$$

$$W_{\text{out}} = 2.4.5-\text{T emissions rate (g/hr)}.$$

- h. DRE higher than shown because DLVs were used for emissions data.

concentration occurring during Test Burn 5 (Section V.C.3.c). At the stack gas flow rate for this test burn (12,380 standard m³/hr), the hourly rate of released hydrogen chloride is calculated at 3.7×10^{-6} kg/hr, which is insignificant compared to the limit of 1.8 kg/hr in 40 CFR 264.343(b).

3. Particulate Emissions

The particulate concentrations in the five test burn MM5 composite samples ranged between 17.2 and 49.7 mg/dscm corrected to 6% excess oxygen. The maximum particulate concentration, which occurred during Test Burn 5 (Section V.C.3.d), is well below the limit of 180 mg/dscm in 40 CFR 264.343(c).

C. LIQUID WASTE EFFLUENTS

A goal in any restoration process is to not generate additional hazardous waste, such as liquid waste. The MWP-2000 incinerator system uses water in the air pollution control train. Potential sources for collecting contaminated water are at the packed tower and ejector scrubber, previously described in Section II.E. The effluent neutralization tank (ENT) represents the initial collecting point from each of these features. ENT water samples were collected from each test and sampled to evaluate waste stream performance. To ensure that permit requirements were satisfied, the ENT samples from all tests were subsequently collected as one volume at the POTW holding tank and analyzed before discharge for POTW treatment. The following subsections discuss compliance with the permit requirements and nonhazardous goal performance of the process liquid effluent.

1. POTW Permit Compliance

The POTW permit (Appendix D, Exhibit 3) required that there be no detectable 2,3,7,8-TCDD, 2,4-D, or 2,4,5-T in the liquid effluent released to the NCBC line for POTW treatment. The analytical results for the POTW

holding tank sample demonstrated that these conditions were satisfied. HRMS results show PCDD/PCDF (tetra, penta, hexa congeners) were not detected with detection levels below 0.1 ppt (Table 22). The specific analyses for 2,3,7,8-TCDD and 2,3,7,8-TCDF also showed no detectable quantities at DLVs of 0.076 and 0.12 ppt, respectively. The two herbicides were not detected either, with DLVs of 1.0 and 0.1 µg/L for 2,4-D and 2,4,5-T, respectively (Table 23).

2. System Performance

The analytical results of ENT samples from the individual test burns show that, regardless of operating conditions, neither PCDD/PCDF nor organics (Tables 19 and 20) were detected. The DLVs for the PCDD/PCDF were quite low at less than 0.1 ppt. While not as sensitive, the DLVs for the organics were also low (<80 ppb) but varied considerably by constituent.

Although inorganics in the ENT samples were not analyzed, trend evaluation of inorganic buildup is possible from the inorganic concentration results for the composite POTW holding tank sample. By comparison with the data for the background water sample (WB-1) shown below, it is observed that significant concentration increases occurred for arsenic, cadmium, nickel, and selenium. The status for barium is unknown because of a high DLV for the POTW sample compared to the WB-1 sample. Arsenic was detected in the feedstock soil samples for all test burns. Cadmium, nickel, and selenium were only marginally detected in one or more test burn feedstock soil samples. The pathway occurs through scrubbing out aerosol particles in the incinerator gas stream.

<u>Metal</u>	<u>Supply Water Background Concentration ($\mu\text{g/L}$)</u>	<u>POTW Sample Concentration ($\mu\text{g/L}$)</u>
Arsenic	<1	13
Barium	20	<204
Cadmium	<1	12
Nickel	<10	30
Selenium	<1	60

For the feedstock conditions that prevailed during the test burns, the incinerator process demonstrated that the liquid effluent waste generated during the operations was nonhazardous. The margins that occurred suggest that substantially higher metal concentrations in the feedstock occur with this process and still produce nonhazardous liquid waste; a quantitative envelope, however, remains undefined.

D. AMBIENT AIR QUALITY

1. Particulate

During all phases of operation monitored by ambient air sampling, the particulate concentrations were shown to be quite low ($<0.11 \text{ mg/m}^3$ average concentration for any sample) compared to the TLV for total dust 10 mg/m^3 . Consistent rains during the operations period contributed to the low concentrations.

Table 34 shows a comparison of the average particulate concentrations according to sampler location and type (where located side-by-side). Inconsistency in the data precludes drawing any trends regarding activities and sampler location. For example, the one day data for December 4, when soil excavation and drying occurred, show the upwind control location having the highest concentration of the three positions by a substantial amount. This is not to be expected unless the general

Table 34. Comparison of ambient air particulate concentrations according to sampler location and type

<u>Date</u>	<u>Location</u>	<u>Average Particulate Concentration^a ($\mu\text{g}/\text{m}^3$)</u>	
		<u>PUF-Type</u>	<u>SHV-Type</u>
12-4-85 ^b	Upwind, control	95	-- ^c
	Onsite, local exposure	74	46
	Downwind, offsite	78	28
12-5/6/7/8/15-85 ^d	Upwind, control	78 ^d	-- ^c
	Onsite, local exposure	-- ^e	62 ^f
	Downwind, offsite	88 ^d	50 ^f

a. Data are referenced from Table 10.

b. Activities pertained to excavation and solar drying of contaminated soil for the test burns.

c. No SHV sampling at the upwind location.

d. This time period is shown because the filters for the upwind and downwind PUF samplers were not changed during this duration. Soil drying occurred on 12-5; test burns occurred during the remaining days.

e. A PUF sample was taken only on 12-15 with an average concentration of 42 $\mu\text{g}/\text{m}^3$.

f. SHV samples were taken each day. The average concentration for the entire duration was determined by dividing the total particulate mass for the four days by the total air flow for the same days shown in Table 10.

background conditions (which can vary locally) dominate the site activities. The data from sampling during the test burns appear more logical but show little differences. A more interesting trend is the consistent bias between PUF and SHV sampler results. In all cases the PUF results were higher and by a considerable amount (61-179 percent). The reason for this bias is not readily explainable. The differences in sampler flow rate and sampling media could contribute to the bias and should be considered in future ambient air sampling activities.

2. HO Constituents

For the phases of operation in which the ambient air monitoring samples were analyzed (i.e., soil drying and test burns), the air concentrations of 2,4-D and 2,4,5-T (Table 25) were at least a million times below the TLV of 10 mg/m^3 that applies to both compounds. This demonstrates that the activities associated with this soil restoration process can be done safely near the work site without jeopardy to the workers.

There were no side-by-side sampler herbicide data sets to compare the results for the PUF and SHV samplers. The onsite PUF sample P-745 and downwind offsite SHV sample H-13 represent the sample time period during Test Burns 5 and 6 on December 15; the 2,4,5-T concentration for P-745 is substantially higher than the concentration for H-13 (Table 25). The 2,4,5-T was almost entirely found on the top two PUF plates for P-745, rather than its upstream filter, demonstrating that this type of sampler is more effective for organics than is the SHV type.

E. PROBLEMS ENCOUNTERED AND POTENTIAL SOLUTIONS

During testing, numerous mechanical problems occurred that affected the accomplishment of the verification test burns. All of the problems were either mechanical or personnel related rather than technological failure of the incinerator system. Future applications of this technology could be suitably modified without significant difficulty.

1. Solids Feed System

a. Soil Bridging in Feed Hopper

One of the most significant problems with the solids feed system was its inability to provide the incinerator with sufficient feedstock material. Because of this problem, the incinerator was not able to run at its fully rated capacity.

The solids feed problem was largely caused by moist soil bridging above the rotary auger. Once a bridge occurs, no feedstock is able to be fed to the incinerator. To solve the problem during testing, a worker dressed in full Level C protective clothing was stationed at the feed hopper. When bridging occurred, he used a long steel rod to knock the soil free from the sides of the hopper. At the time of testing, this solution was viewed as a temporary means to ensure a successful test series; for long-term operations, however, such a solution would be difficult to sustain because of worker fatigue and heat stress. Additionally, the labor costs associated with such a solution would be quite expensive.

b. Shredder Reliability

Another significant problem with the solids feed system was the inability of the shredder to adequately shred the large, very hard pieces of cement stabilized soil to a size suitable for feed to the incinerator through the rotary auger. As a result, workers dressed in full Level C protective clothing had to manually remove those large pieces from the weigh hopper. This manual operation reduced the on-line time of the shredder, thus reducing the throughput capability of the incinerator system.

c. Weigh Hopper Scale and Data Acquisition

During the test burns, the mass feed rate to the kiln was calculated by determining the initial and final weights of the weigh hopper before and after a load of soil was placed into the hopper. The mass feed rate was then manually calculated by dividing the differential mass of soil by the elapsed time between bucket loads of soil.

Feedstock was placed into the weigh hopper at approximately 15 to 20 minute intervals and each test burn lasted for approximately 1 to 1.5 hours. Therefore, the number of available data points obtained during the test burns was quite small. Additionally, due to the duration between data points, the operators were unable to accurately control the mass feed rate and maintain steady state operations. This inability caused the failure of Test Burn 4.

Because of the variability and controllability of mass feed rate, difficulties during routine operations were expected. Therefore, steps were taken to install electronic load cells on the weigh hopper and link their data signals to the data acquisition system. Subsequent technical reports in this demonstration series will evaluate the usage of those load cells.

2. Cyclone Separator Design

The cyclone separator between the kiln and SCC caused numerous secondary problems that ultimately caused a significant reduction in mass feed rate. Because of the improper design, significant quantities of large particulate were carried over from the kiln into the SCC. That particulate was then carried into the boiler where it plated out onto the boiler face plate and into the boiler fire tubes. The particulate on the boiler face plate caused significant reduction in the openings to the boiler's fire tubes, thus resulting in a high frictional and entrance loss pressure drop. The particulate deposited in the boiler tubes resulted in reduced thermal efficiency of the boiler, thus reducing the quantity of steam produced.

The reduced quantity of steam produced in the boiler reduced the amount of draft from the ejector scrubber. The reduced ejector scrubber draft, in addition to the boiler's increased pressure drop, significantly detracted from the incinerator's ability to draw the products of combustion and water vapor from the moist soil through the system. When the draft produced by the jet scrubber is insufficient, the mass feed rate must be reduced to reduce the volume of water vapor and combustion products in the kiln and SCC.

In short, failure of the cyclone significantly affected the operation of the boiler and ejector scrubber, which ultimately forced a reduction in the mass feed rate.

One of the reasons for the poor particulate collection efficiency of the cyclone was that the vortex tube in the cyclone was too short. The short vortex tube allowed the particulate laden gases to "short circuit" and not be impacted against the cyclone wall. Only one of the two cyclones was used. Because the cyclones are in parallel, the use of one cyclone permitted higher velocities in the cyclone, which was hoped to increase the particulate collection efficiency. The use of both cyclones simultaneously would have significantly compounded the problem.

Another problem with the cyclone was that the collected particulate did not fall downwards to the ash drag as intended. Instead, the particulate collected in the cyclone, thus enhancing the short circuit effect described above.

The residual particulate in the cyclone also caused an accident that could have had potential serious consequences. When the cyclone plugging problem was discovered, operational personnel attempted to free the particulate by hammering on the side of the cyclone and cyclone downcomer. The particulate released suddenly and fell through the downcomer into the ash quench. The sudden influx of hot particulate into

the open ash quench caused the hot ash quench water and steam to erupt and splash a nearby worker in the face. Fortunately, the worker reacted quickly to avoid serious burns; no lost time was incurred by the worker.

Because feedstock particle sizing may not be adequately known before starting a soil restoration incinerator operation, characterization test runs are suggested for the range of feedstock materials. By evaluating particle carryover at different operating conditions, the system can be evaluated for optimum operating parameters. Or design changes may be appropriate. In this case, the particulate carryover problem was subsequently resolved by slowing the kiln rotation speed. This reduced the entrainment of small particles in the air flow passing through the kiln.

3. Boiler Design

As mentioned in the previous section, the particulate collected in the boiler caused reduced thermal efficiencies and increased pressure drop across the boiler. When that occurs, the boiler must be cleaned.

To clean the boiler, a large 60 in. diameter plate must be unbolted and removed to gain access to the rear end of the boiler. Then a long "bottle brush"-like device is inserted into each of the fire tubes, one at a time. The brush mechanically scours the fire tube and removes the particulate. The face plate is manually cleaned via an access hatch in the crossover T section between the SCC and the boiler.

Cleaning the boiler requires approximately 24 hours as designed because the incinerator must be cooled down to allow access to the front and rear of the kiln. Additionally, significant time is required to remove approximately 25 bolts from the rear boiler plate. A redesign of the boiler end plate could allow individual access to each of the fire tubes during operation. By changing the boiler end plate, cleaning of the boiler tubes could be conducted when the incinerator is on-line; no lost processing time would be required. The face plate cleaning would still

require cooling of the incinerator and, hence, lost processing time; however, that cleaning is anticipated to occur less frequently and require less time than the tube cleaning.

4. Temperature Controllability

Overall controllability of temperature in the SCC during the test burns was not a significant problem; the maximum and minimum temperature variance averaged 49°F and the maximum temperature variance was 78°F observed during Test Burn 5. The SCC temperature is manually controlled by the operator who adjusts the fuel setting. The plot in Figure 34 for Test Burn 5 shows that the operator was slow to observe and respond to the decreasing temperature that was indicated. Not until the temperature decreased below the 2100°F limit was a sufficient response made to increase the temperature back above the limit value. The SCC temperature decrease below the 2100°F limit in Test Burn 6 (Figure 34) was largely caused by starting the test with the temperature too close to the limit (2120°F) and represents another operator lapse. The actual variance in temperature was small as shown by the temperature plot. In both of these tests, an automatic trip circuit stopping the feed would normally have occurred; however, the circuit was bypassed for the test burns because of their shortness in duration. This did not interfere with their accomplishment.

The kiln temperature, however, was less controllable than the SCC temperature. The maximum and minimum temperature variance averaged 137°F and the maximum temperature variance was 233°F observed during Test Burn 5. No temperature limits were in jeopardy because the acceptable range was wide compared to the control variance.

The kiln temperature is expected to have a wider variation than the SCC because of the high specific heat of the feedstock soil as compared to the low specific heat of the gases leaving the kiln and entering the SCC (i.e., it is easier to heat gases and keep them hot than it is to heat soil and keep it hot). Additionally, the SCC burner is

rated at 24 million Btu/hr while the kiln is rated at 14 million Btu/hr. Therefore, the SCC has more thermal capacity and is thus less susceptible to input variations.

5. Weather

Foul weather caused most of the delays during the test burns campaign. Obviously, nothing can be done about nature; however, it is recommended that schedules for future tests include allowances for weather. Only one test should be planned for any operational day and one should schedule at least twice as many days for the test campaign as there are stack tests to be performed.

6. RCRA Permitting

The Air Force and EPA Region IV worked under an understanding that permission to commence operation was contingent upon a successful verification test burn and prior RCRA six nines certification of an incinerator that was identical to the MWP-2000 incinerator. The "twin sister" incinerator was located in El Dorado, Arkansas, and was built, operated, and tested by Enesco Environmental Services.

In early December 1986, just before the verification test burns at NCBC, EPA Region VII notified Enesco that the RCRA six nines test certification test performed in March 1986 on the incinerator located in El Dorado had failed; hence, that incinerator was not permitted to process F027 type waste. Enesco did not inform EG&G Idaho or the Air Force of the deficiency. As a result, the verification test burns were performed as planned and the goals of the test, i.e., demonstration of the delisting potential of the processed soil and demonstration of cleanliness of other process effluents, were achieved.

Although the goals of the verification test burns were met, EPA Region IV denied permission to commence routine operation because neither

the El Dorado incinerator nor the MWP-2000 incinerator at NCBC was certified as a six-nines incinerator. No data existed to show that the incinerator could process F027 waste and comply with 40 CFR 264.

Additional details of the permitting problems and additional testing associated with the incinerator certification are presented in the technology report for the trial burn Reference 2 of the MWP-2000 incinerator system at the NCBC.

SECTION VII

CONCLUSIONS AND RECOMMENDATIONS

A. CONCLUSIONS

The United States Air Force Engineering Services Center in cooperation with EG&G Idaho, Versar Inc., and ENSCO performed a field demonstration of the ENSCI owned MWP-2000 incinerator system with dioxin-contaminated soil at NCBC in Gulfport, Mississippi. A total of approximately 100 tons of contaminated soil were processed with five verification test burns being evaluated. This demonstration was accomplished in December 1986. Specific conclusions about soil treatment capabilities, process performance, waste effluents, ambient air conditions, and operational problems follow.

1. Soil Treatment

All test burns achieved the AFESC goal that the treated soil PCDD/PCDF congener sum (tetra, penta, and hexa) be less than 1.0 ppb. The congener sum ranged from 0.009 to 0.021 ppb with the maximum concentration occurring for a test burn during conditions of lowest average kiln temperature (1355°F) and highest average soil feed rate (6.3 tons/hour).

Soil-to-ash removal efficiencies (SAREs) of at least four nines were achieved for 2,3,7,8-TCDD and total TCDD. The calculated soil SAREs ranged between 99.9921 and 99.9966 percent for 2,3,7,8-TCDD and between 99.9952 and 99.9984 percent for total TCDD. In all cases these represent lower bounds because neither of the species was detected in any of the treated soil samples, and the DLVs obtained by HRMS were used in the calculations.

Calculated SAREs of five nines for test burns and four nines for the other three test burns were achieved for 2,4,5-T. The SAREs ranged between 99.9957 and 99.9998 percent. In all cases these represent lower

bounds because 2,4,5-T was not detected and the DLV (2 ppb) was used in the calculations. Most significantly, the highest SARE was obtained during the test burn of lowest average kiln temperature and highest average soil feed rate. These results suggest that the MWP-2000 incinerator process can achieve at least SAREs of six nines for this herbicide.

While 2,4-D was not detected in the treated soil (DLV of 20 ppb), the SARE results for the herbicide were lower than for 2,4,5-T with a range between 99.9130 and 99.9994 percent. This was due to lower 2,4-D concentrations in the feedstock soil samples and higher DLV (factor of 10) in the treated soil samples.

Cleanup of 2,4,5-trichlorophenol, observed in the feedstock soil samples, occurred; however, the reduction evaluation was limited because of low initial concentrations and high DLVs. The best example observed showed a concentration of 0.21 ppm in the treated soil sample where the concentration in the feedstock soil sample for the same test burn was 8.8 ppm.

Although only found in the ppb range in the feedstock samples, some reduction in concentrations for three PAHs [fluoranthene, benzo(b)fluoranthene, and benzo(a)pyrene] was observed. The best example was the reduction of fluoranthene in the feedstock soil sample of one test burn at 110 ppb to a concentration of 2.7 ppb in the treated soil sample.

Within the variability of individual analyses, there were no observed concentration differences of any significance for metals between feedstock and treated soil samples.

The treated soil produced by the incinerator process from NCBC HO-contaminated soil was evaluated for delistability to EPA requirements. Because the treated soil is not corrosive, ignitable, or reactive and because it passes the requirements for the EP Toxicity Test, the requirements of 40 CFR 261.21-261.24 can be satisfied. The hazardousness of the contaminated soil can be reduced to concentrations of dioxins that

are significantly less than 1 ppb, so that if delisting failed, the EPA rules for landfill disposal of dioxin-contaminated material could still be met. The concentrations of the HO-related organics detected in the feedstock above 1 ppm were removed to nondetectable levels well below 1 ppm in the treated soil. The concentration of 2,3,7,8-TCDD in the processed soil was non-detectable using high resolution GC/MS techniques with a DLV of 1.1 ppt; therefore, the processed soil should meet the delisting criteria established via the VHS/OLM models specified in 51 FR 41082-4100 (Reference 35).

2. Incinerator Performance

The MWP-2000 incinerator system demonstrated that two of the three performance standards could be met. These were chloride and particulate emissions. Sample analysis of stack gas showed chloride concentrations of $0.29 \mu\text{g}/\text{m}^3$ or less for all test burns, which is well below the EPA limit of 1.8 kg/hr in 40 CFR 264.343(b). Also particulate concentrations were 49.7 mg/dscm or less for all test burns, which is well below the limit of 180 mg/dscm in 40 CFR 264.343(c).

The destruction and removal efficiency of 2,3,7,8-TCDD could not be demonstrated by the process because the dioxin concentration in the HO-contaminated soil was not sufficiently high to be able to calculate a DRE meeting the EPA limit of six nines in 40 CFR 264.343(a). No 2,3,7,8-TCDD was detected in the stack gas samples and HRMS was used to achieve lowest possible detection levels ($0.22\text{-}0.32 \text{ ng}/\text{m}^3$). Four nines were demonstrated ranging from 99.9968 to 99.9985 percent.

Destruction and removal efficiencies of six nines were demonstrated for the herbicides 2,4-D and 2,4,5-T on at least one test burn. Because of its higher initial concentrations in the HO-contaminated soil and lower analytical detection level (factor of 10), the DRE results were better for 2,4,5-T than for 2,4-D with a range of 99.9968 to 99.9999 percent. Two test burns met six nines; however, EPA recommends that this requirement be met by three test burns (Reference 37). The 2,4-D range

was 99.9736 to 99.9999 percent with one test burn having a DRE of six nines. Because neither of the herbicides was detected in the gas samples, the DLVs were used in the DRE calculations giving a lower bound value. One of the test burns showing a DRE of six nines for 2,4,5-T occurred during the most severe operating conditions among the five test burns. The herbicide DRE results provide a significant indication of the incinerator system capability to meet the EPA DRE performance requirements for POHCs.

3. Liquid Waste Effluents

For the feedstock conditions that prevailed during the test burns, the incinerator process demonstrated that the liquid effluent waste generated during the operations was nonhazardous. No 2,3,7,8-TCDD, 2,4-D, or 2,4,5-T were detected in the composite sample of the liquid waste stored for subsequent release to the NCBC line for POTW treatment, which also satisfied the POTW permit issued by the State of Mississippi for the project. The detection levels were well below EPA requirements where a standard existed. Detected metals in the liquid waste were at concentrations well within EP Toxicity Test limits.

4. Ambient Air Quality

During all phases of operation monitored by ambient air sampling, the particulate concentrations were shown to be quite low (<0.11 mg/m³ average concentration for any sample) compared to the TLV for total dust at 10 mg/m³. Ambient levels of 2,4-D and 2,4,5-T were also shown to be very low, being six orders of magnitude below the TLV of 10 mg/m³ that applies for both compounds. These results demonstrate that the activities associated with this soil restoration process can be done safely.

5. Problems Encountered

During testing numerous mechanical problems occurred that affected the accomplishment of the verification test burns and will likely impact the subsequent soil restoration process unless resolved. All of the problems were either mechanical or personnel-related rather than a technological failure of the incinerator system.

Three significant problems were associated with the soil feeds system: (a) moist soil bridging above the rotary auger in the feed hopper, (b) shredder reliability due to the nature of the cement-stabilized NCBC soil, and (c) determination and control of mass feed rate. The third problem was resolved by installing electronic load cells on the weigh hopper and transmitting the signals to the data acquisition system; however, adequacy of this solution will be demonstrated during the soil restoration phase of the project. The other problems require long-term resolution.

Improper design of the cyclone separator caused significant quantities of particulate to be carried over from the kiln into the SCC. That particulate was then carried into the boiler where it plated out onto the boiler faceplate and into the boiler fire tubes. A partial resolution was made during the test burns to increase the air velocities in the cyclone by blocking off one of the two parallel cyclones. A longer vortex tube is needed. An additional problem was that particulate tended to collect within the cyclone rather than fully fall downwards by gravity to the ash drag as intended.

Cleaning of the boiler, resulting from the beforementioned particulate carryover proved to be awkward to perform and operationally time consuming. Redesign of the boiler end plate could improve this situation.

Review of SCC temperature records shows that improved incinerator process operator awareness is needed to maintain good temperature control. Cases were noted where initial temperatures were manually set too close to limits that could activate automatic trips and where temperature drifting occurred without response for substantial time, thus also causing temperatures to reach limits activating automatic trips. This may have been caused, in part, to inexperience at the beginning of the project and variability within the NCBC feedstock.

B. RECOMMENDATIONS

1. Based on the analytical data from the verification test burns, the MWP-2000 incinerator process should be considered as an acceptable technology for treating dioxin-contaminated soils at relatively high feed rates (5-6 tons/hour). This technology can process soil and other inorganic solids with little pretreatment and uses conventional equipment.
2. The MWP-2000 incinerator process also should be considered as a technology for detoxifying soils contaminated with other organic compounds.
3. Because the DRE performance for 2,3,7,8-TCDD could not be demonstrated because of low concentrations in the feedstock, it was recommended that trial burn testing at NCBC be performed with surrogates acceptable to the EPA to demonstrate six nines DRE.
4. It was recommended that the problems identified as a result of this testing be investigated by ENSCO for possible design and/or procedural changes that would improve the system operability and reliability.

5. At the beginning of a restoration project, there should be emphasis on supervision and training of system operators to ensure understanding and awareness of control responsiveness, especially to avoid reaching operating limits that require mitigating actions.
6. Schedules of restoration tests should include allowances for seasonal weather conditions. In areas such as the Gulf region where weather changes can occur suddenly, it is advisable to plan for only one test during any operational day. Also, twice as many days should be scheduled as there are stack tests to be performed.
7. Documented RCRA certification status of any restoration technology process should be clearly made known to the contracting agency of a restoration project prior to committing to field activities. This includes making known any process configuration or procedural changes that might invalidate an existing RCRA certification and cause undue delays because of subsequent interactions required with the EPA Regional Office having administrative jurisdiction over the project.

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